PN-ABP-83
84293

Land and Water Resources of the BLUE NILE BASIN

ETHIOPIA

FINCHAA RIVER SUB-BASIN

A.I.D.
Reference Center
Room 1656 NS

Prepared for the Department of State
Agency for International Development

By the United States Department of the Interior
Bureau of Reclamation

1963

LAND AND WATER RESOURCES OF THE BLUE NILE BASIN

ETHIOPIA

FINCHAA RIVER SUB-BASIN

United States
Department of the Interior

Bureau of Reclamation

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
WASHINGTON 25, D. C.

IN REPLY REFER TO: 220

JAN 6 1964

Mr. Stephen Christmas
Officer-in-Charge
Horn of Africa
Department of State
Agency for International Development
Washington, D. C. 20523

Dear Mr. Christmas:

In accordance with your request of October 4, 1963, we have prepared an advance reconnaissance report for the Finchaa Project in the Blue Nile River Basin in Ethiopia. It will be noted that the report also contains information on the Amarti-Neshe Project in the same river basin.

During the early stages of the Blue Nile investigation program, the Finchaa and the Amarti-Neshe were considered as one project with the water supply for the project lands coming from the Finchaa River. Project data, particularly geology and land classification, were prepared on the basis of a single project. Later it was found that the water supply from the Finchaa River was not adequate to irrigate all of the project lands and that the Amarti and Neshe Rivers offered good possibilities for the development of hydroelectric power. The plan was then separated into the two projects.

Since the ultimate development of the Finchaa River Basin will include both projects and since the data are interrelated, it appeared advisable to report on both projects. The projects will also be covered in the forthcoming Blue Nile Report.

The reconnaissance investigation and evaluation of the Finchaa Project at this stage indicate its economic feasibility. However, further detailed surveys and analysis are necessary before a final determination of feasibility can be made.

For the purpose of the economic evaluation of the irrigation project, we have used farms averaging about 17 hectares (40 acres) in size. This is consistent with our understanding that the objectives of the Imperial Ethiopian Government are to improve

the national economy and raise the standard of living of the Ethiopian people. The 17-hectare farm would support these improvements, while smaller farms would tend to perpetuate the present subsistence operation.

During the past few years, the IEG has developed several projects --Wonji sugar, Koka powerplant, Zula dam, Tendaho, and others --somewhat independently, with only limited, if any, coordination. For initial development, this is not serious. However, as the development is accelerated and the demands upon Ethiopian resources increase, this lack of coordination could have serious effects. Therefore, it is recommended that the IEG give consideration to the establishment of a central agency to administer and coordinate the long-range development program.

From an engineering standpoint, the Finchaa Project appears to be feasible.

The economic success of the Finchaa Project is dependent upon the Ethiopian people, who must plan and direct the development, and upon those who will operate the facilities and the farms. If they accept this responsibility with a sincere desire for success and if they apply their talents with vigor and enthusiasm, it can be a successful venture. The resources are there. It is up to the Ethiopian people to develop and use them wisely.

Sincerely yours,

Commissioner

TRANSLITERATION

Certain inconsistencies in the spelling of names may be noted on maps and drawings and in the text. Because of the difficulty in transliterating Arabic, Amharic, Galla, and Italian into exact English equivalents, some variation of spellings and even in names occurs in the basic maps and drawings. It will be noted, however, that the phonetic pronunciation of names is similar regardless of spelling, except in the rare situation where an entirely different English name is used because of long established convention. An example of the latter is the name for the principal river, Blue Nile, which in Amharic is known as Abbay (Abbai). Addis Ababa is often referred to as Addis Abeba. Other examples are as follows:

Lekkemt	Nekemti
Acachi	Akaki
Jima	Jimma, Gima
Langano	Langana
Shashamane	Shashamana
Shewa	Shoa

In western and northwestern Ethiopia, local usage of Arabic words for streams and mountains is usually retained. For example, "Jebel" denotes mountain and "Khor" identifies a watercourse. In addition, the English name or abbreviation sometimes precedes the Arabic term, as with "Mt. Jebel Kir."

Local usage sometimes requires different names along different lengths of the same river. For example, the Guder River is known as Tacur, Bello, and Guder.

Wherever possible, a consistent spelling has been used for identical places in this report.

ABBREVIATIONS, CONVERSION FACTORS, AND ETHIOPIAN MONETARY AND CALENDAR EQUIVALENTS

Abbreviations:
- EELPA = Ethiopian Electric Light and Power Authority
- IEG = Imperial Ethiopian Government

Conversion Factors: Metric-English Systems
- 1 meter (m.) = 39.37 inches = 3.2808 feet
- 1 kilometer (km.) = 0.6214 mile = 3,280.8 feet
- 1 square meter (sq. m.) = 1.196 square yards = 10.764 square feet
- 1 hectare (ha.) = 10,000 square meters = 2.471 acres = 1/100 square kilometer
- 1 hectoliter = 0.1 cubic meter = 2.838 bushels; 26.417 gallons
- 1 square kilometer (sq. km.) = 0.3861 square mile = 100 hectares = 247.1 acres
- 1 cubic meter (cu. m. or m^3) = 1,000 liters = 1.308 cubic yards = 35.31 cubic feet
- 1 cubic meter = 0.000,810,7 acre-foot
- 1 acre-foot = 1,233 cubic meters
- 1 kilogram (kg.) = 2.204 pounds
- 1 kilogram per hectare (kg/ha) = 0.8926 pound per acre
- 1 metric ton = 2,204 pounds = weight of 1 cubic meter of water
- 1 kilogram per square centimeter (kg./sq. cm.) = 14.22 pounds per square inch = 32.8 feet of water
- 1 cubic meter per second (m^3/s.) = 35.31 cubic feet per second (c. f. s.)
- 1 English horsepower = 550 foot-pounds per second
- 1 metric horsepower = 75 kilogram-meters per second
- 1 metric horsepower = 0.9863 English horsepower = 735.45 watts
- 1 cubic meter of water per second under 1 meter head = 9.81 kilowatts at 100 percent efficiency
- 1 million cubic meters of water under 1 meter head = 2,730 kilowatt-hours at 100 percent efficiency

Temperature Conversion:

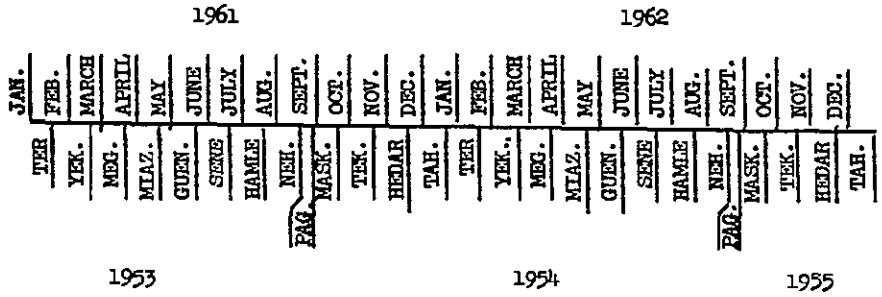
Centigrade: $C. = \frac{5}{9}(F° - 32)$ Fahrenheit: $F. = \frac{9}{5}C° + 32$

Ethiopian-United States Monetary Values: Rate of exchange used in this report
- 1 United States dollar (US$1.00) = 2.50 Ethiopian dollars (Eth$2.50)

Ethiopian Calendar (30-day months, except Pagumen):

Maskaram	= Sept. 11 - Oct. 10	Miazia	= April 9 - May 8
Tekemt	= Oct. 11 - Nov. 9	Guenbot	= May 9 - June 7
Hedar	= Nov. 10 - Dec. 9	Sene	= June 8 - July 7
Tahessas	= Dec. 10 - Jan. 8	Hamle	= July 8 - Aug. 6
Ter	= Jan. 9 - Feb. 7	Nehasse	= Aug. 7 - Sept. 5
Yekatit	= Feb. 8 - March 9	Pagumen	= Sept. 6 - Sept. 10
Megabit	= March 10 - April 8		

UNITED STATES OR GREGORIAN CALENDAR



ETHIOPIAN CALENDAR

CONTENTS

	Page
TRANSMITTAL LETTER	
TRANSLITERATION	i
CONVERSION FACTORS	ii
TABLE OF CONTENTS	iii
LIST OF TABLES	vii
LIST OF DRAWINGS	xiii
LIST OF PHOTOGRAPHS	xvii
SECTION I - INTRODUCTION	
Authority and Scope	1
Summary	5
Conclusions	9
Recommendations	10
SECTION II - GENERAL DESCRIPTION	
Basin Description	13
Projects Area Description	14
Population	14
Present Economy	14
Climate	15
Quality of Water	15
SECTION III - HYDROLOGY	
Finchaa Project	21
Operation Study	21
Estimate of Available Flow	22
Area-Capacity Relationships	22
Monthly Power Releases	23
Irrigated Area	23
Spillway Design Flood	23
Flood Frequency	23
Outlet Capacity	23

	Page
Amarti-Neshe Project	24
Operation Study	24
Estimate of Available Flow	24
Area-Capacity Relationships	24
Monthly Power Releases	24
Irrigated Area	39
Spillway Design Flood	39
Flood Frequency	39
Outlet Capacity	39
SECTION IV - GEOLOGY	
General Geology of the Area	43
Geologic Reconnaissance	44
Seismology	44
Ground Water	44
SECTION V - PLANS AND ESTIMATES	
Comprehensive Plan of Development	45
Finchaa Project	45
Plan of Development	45
Project Features	46
Finchaa Dam and Reservoir	46
Site Geology	47
Construction Materials	48
Access to Sites	49
Power Diversion Dam	49
Power Tunnel and Penstocks	49
Powerplant	50
Transmission Plant	51
Irrigation Diversion Dam	54
Main Canals	54
Distribution System and Drains	55
Service Facilities	56
Estimates of Construction Cost	56
Plan Selection and Alternatives	57
Amarti-Neshe Project	59
Plan of Development	59
Project Features	59
Amarti-Neshe Dams and Reservoirs	59
Site Geology	61
Construction Materials	62
Access to Sites	63
Power Canal	63
Power Tunnel and Penstocks	63
Powerplant	64

	Page
Transmission Plant	65
Irrigation Diversion Dam	66
Main Canals	66
Distribution System and Drains	67
Service Facilities	67
Estimates of Construction Cost	67
Plan Selection and Alternatives	68
SECTION VI - IRRIGATION DEVELOPMENT	
Finchaa Project	71
Introduction	71
General Description	71
Location and Extent	71
Physiography	72
Transportation and Habitation	72
Present and Potential Land Use	73
Project Lands	73
Topography and Land Development	73
Drainage	75
Soils	75
Land Classification	77
Agricultural Economics	81
Agricultural Conditions before Project Development	81
Agricultural Conditions after Project Development	81
Alternative Crops	89
Livestock	102
Land Settlement	102
Amarti-Neshe Project	103
SECTION VII - POWER	
Background	105
Factors in Power Market Analysis	105
Power Market Areas Studied	105
Physical Characteristics	106
Population	107
Occupations of Labor	108
Natural Resources	110
Principal Economic Activities	112
Income	129
Development of Electric Energy Use	131
National Economy	132
Mineral Products	143
Iron and Steel	145
Miscellaneous	146
Other (Transport and Communications)	146
Public Consumption and Illumination	149

	Page
Present Electric Rates	151
Cost of Electricity and Other Energy Sources	151
Past, Present, and Estimated Future Power Requirements	156
System Conditions Considered for this Study	157
Existing Power Systems	157
Past, Present, and Future Requirements	160
Energy and Demand at Load Centers	165
Summary	178
Estimated Future Need for Additional Generator Capacity--1964-1967	178
Power Facilities Planned or Under Consideration --1964-1967	181
Estimated Future Deficiency in Power Supply --1968-1980	182
Finchaa Sub-Basin as a Source in Meeting Future Deficiencies in Power Supply	182
Reserves	188
System Installation Schedule	188
Estimated Power Costs of Alternative Sources	189
Finchaa Hydroelectric Powerplant and Related Facilities	189
Neshe Hydroelectric Powerplant and Related Facilities	191
Summary	193
SECTION VIII - ECONOMIC ANALYSIS	
Finchaa Project	195
Benefits	195
Costs	200
Benefit-Cost Analysis	202
Amarti-Neshe Project	209
Benefits	209
Costs	209
Benefit-Cost Analysis	212
SECTION IX - ADMINISTRATION AND OPERATION	
Governmental and Administrative Organization	217
Agricultural Operations	219
National Goals	219
Farm Family Income Objective	219
Development Period	221
Settler Selection and Assistance	221
Training Farm	222
Experimental Farm	222
Manager of Agriculture	223
Agricultural Development Commission	224
Future Studies	224
Electric Power Operations	224
Central Organization	224
Project Power Operations	228

LIST OF TABLES

Number	Title	Page
II-1	Climatic Stations in or near Abbay Basin in Ethiopia	17
II-2	Temperature at Ambo Agricultural School in ° C. --Daily Minima	18
II-3	Temperature at Ambo Agricultural School in ° C. --Average Daily and Daily Maxima	19
II-4	Precipitation in mm. at Ambo Agricultural School	20
III-1	Reservoir Operation Study--Finchaa Reservoir	25
III-2	Computation of Finchaa Farm Delivery Requirement	28
III-3	Inflow Design Flood--Finchaa Damsite	29
III-4	Flood Frequency at Damsites--Finchaa and Amarti-Neshe Projects	30
III-5	Reservoir Operation Study--Neshe and Amarti Reservoirs	31
III-6	Area-Capacity Tables--Neshe and Amarti Reservoirs --showing 50- and 100-year Sediment Distribution	34
III-7	Maximum Probable Flood--Amarti and Neshe Combined	40
III-8	Maximum Probable Flood--Neshe (without Amarti)	41
V-1	Detailed Cost Estimates--Finchaa Project	follows 56
V-2	Estimated Construction Cost Summary--Finchaa Project	58
V-3	Detailed Cost Estimates--Amarti-Neshe Project	follows 68
V-4	Estimated Construction Cost Summary--Amarti-Neshe Project	69
VI-1	Subreconnaissance Land Classification Standards	79
VI-2	Arable and Irrigable Areas--Finchaa and Amarti-Neshe Projects	80

Number	Title	Page
VI-3	Wholesale Prices in Addis Ababa and in the Finchaa Area	87
VI-4	Summary of Farm Income for Estimating Benefits by Gross Crop Income Method--Finchaa Project--100-hectare Basis	follows 88
VI-5	Summary of Farm Income for Estimating Benefits by Gross Crop Income Method--Finchaa Project--15,000-hectare Basis	follows 88
VI-6	Production and Disposition of Crops, Expressed in Terms of Calories	90
VI-7	Summary of Farm Income for Estimating Benefits by Gross Crop Income Method--Amarti-Neshe Project--100-hectare Basis	follows 103
VI-8	Summary of Farm Income for Estimating Benefits by Gross Crop Income Method--Amarti-Neshe Project--8,490-hectare Basis	follows 103
VII-1	Estimated 1961 Population by Cities	107
VII-2	Population for Blue Nile River Basin by Provinces in the Basin--1961	107
VII-3	1961 Population Estimates--Ethiopia	108
VII-4	Estimated Age Structure in Ethiopia Compared with Data for Some Other Countries	109
VII-5	Land-Use Areas	111
VII-6	Gross Domestic Product Estimates over the 20-year Period	113
VII-7	Estimated Investment during a 20-year Period	114
VII-8	Forecast Trend in Export of Certain Agricultural Products	114
VII-9	Summary of Industry in the 13 Provinces (Year Ended Sept. 10, 1961)	116
VII-10	Index of Economic Trend of Industrial Production (1955 = 100)	117
VII-11	1967 Production Goal for Selected Industrial Products	118
VII-12	Investment in Manufacturing Industry by Years	119
VII-13	Number of Industrial Projects to be Constructed --1963-1967	119

Number	Title	Page
VII-14	Industrial Projects to be Put into Operation--1963-1967	119
VII-15	Forecast Trend in Exports by Sectors	122
VII-16	Forecast Trend in Export of Industrial Products	122
VII-17	Scheduled Mineral Production, by Years (1963-1967)	123
VII-18	Forecast Gross Value of Mineral Production	123
VII-19	Port Assab Traffic--1952-1960	126
VII-20	Planned Investments in the Period 1963-1967	128
VII-21	Employment Totals, Manufacturing Industry--1961	130
VII-22	Use of Electric Power Production by Segments	131
VII-23	Chemical Plants Possible of Development near Assab	140
VII-24	Power and Energy Requirements for Proposed Cement Factories	144
VII-25	Estimated Power Requirements for Factories Planned by 1967	147
VII-26	Tariff in Force, EELPA	152
VII-27	Specific Production Costs, Addis Ababa Steam Plant	153
VII-28	Comparison of Energy Costs in 1958 by Segments of Industry	154
VII-29	Energy Cost other than Electricity	155
VII-30	1961 Interconnected System--Addis Ababa Complex --Cases A and B	158
VII-31	1963 Isolated Systems--Case B	159
VII-32	1961 Interconnected System--Addis Ababa Complex --Cases A and B	159
VII-33	1961 Interconnected System--Addis Ababa Complex	160
VII-34	Past Trends of Energy Requirements (Excluding Eritrea and Production by Industrial Firms)	162
VII-35	Energy and Demand at Load Center--Addis Ababa Complex--Cases A and B	164
VII-36	Energy and Demand at Load Center--Agere Hiywet (Ambo)--Case B	167
VII-37	Energy and Demand at Load Center--Lekkemt--Case B	168

12

Number	Title	Page
VII-38	Energy and Demand at Load Center--Jima--Case B	169
VII-39	Energy and Demand at Load Center--Dessie--Case B	170
VII-40	Energy and Demand at Load Center--South Eritrea --Case B	171
VII-41	Sales by Classes--Addis Ababa Complex--Case A	172
VII-42	Estimated Peak Demand--Interconnected System--Addis Ababa Complex--Case A	173
VII-43	Sales by Classes--Agere Hiywet (Ambo)--Case B	174
VII-44	Sales by Classes--Lekkemt--Case B	175
VII-45	Sales by Classes--Jima--Case B	176
VII-46	Sales by Classes--Dessie--Case B	177
VII-47	Sales by Classes--South Eritrea--Case B	179
VII-48	Estimated Peak Demand--Interconnected System--Case B	180
VII-49	Dependable System Capacity to Meet Peak Demand versus System Coincidental Peak Demand at Plant--1964-1967--Case A or B	181
VII-50	Dependable System Capacity to Meet Peak Demand versus System Coincidental Peak Demand at Plant--1968-1980--Case A	183
VII-51	Dependable System Capacity to Meet Peak Demand versus System Coincidental Peak Demand at Plant--1968-1980--Case B	184
VII-52	Estimated Future Needs for Additional Capacity using Finchaa Sub-Basin Facilities--1968-1980--Case A	186
VII-53	Estimated Future Needs for Additional Capacity using Finchaa Sub-Basin Facilities--1968-1980--Case B	187
VIII-1	Summary of Costs and Annual Cost Equivalents--Finchaa Project	203
VIII-2	Specific and Joint Costs of the Finchaa Project	205
VIII-3	Allocation of Costs of the Finchaa Project by use of the Alternative Justifiable Method	206
VIII-4	Summary of Irrigation Costs--Finchaa Project	207
VIII-5	Summary of Power Costs--Finchaa Project	208

13

Number	Title	Page
VIII-6	Summary of Costs and Annual Cost Equivalents--Amarti-Neshe Project	211
VIII-7	Specific and Joint Costs of the Amarti-Neshe Project	212
VIII-8	Allocation of Costs of the Amarti-Neshe Project by Use of the Alternative Justifiable Method	213
VIII-9	Summary of Irrigation Costs--Amarti-Neshe Project	214
VIII-10	Summary of Power Costs--Amarti-Neshe Project	215
IX-1	Cash Requirement per Family	220

14

LIST OF DRAWINGS

Number	Title	Follows page
6.0-BN-27	Rainfall-Runoff Relationship in Blue Nile Basin	22
2.0-Fi-1	Area-Capacity Curves--Finchaa Reservoir	22
5.2-Fi-2	General Geologic Reconnaissance Map--Neshe-Finchaa Area	44
2.0-BN-92	Finchaa Sub-Basin--Location Map	46
2.0-Fi-2	Finchaa River Project--General Plan	46
2.0-Fi-9	Finchaa River Area--Topography (3 sheets)	46
4.0-BN-74	Profile of Finchaa River--Chomen Swamp Outlet to Mouth	46
OA-23-101	Finchaa Storage Dam and Finchaa Power Diversion Dam	46
2.2-BN-1	Finchaa Dam and Reservoir--Area-Capacity Data	48
4.0-Fi-5	Finchaa Storage Dam--Cross-Section at Damsite at Outlet of Chomen Swamp	48
4.0-Fi-9	Finchaa Power Diversion Dam--Cross-Section at Damsite on Finchaa River below Chomen Swamp	48
4.0-Fi-8	Finchaa River Powerplant--Switching Diagram	52
4.0-BN-23	Device Designations--Symbols for Switching Diagrams	54
4.0-BN-174	Gafarsa Substation No. 2--Switching Diagram--Stages 01 and 02	54
2.0-Fi-6	Amarti-Neshe Project--General Plan	60
OA-23-91	Neshe Dam and Amarti Dam--General Plans and Sections	60
2.2-BN-3	Neshe Dam and Reservoir (without Amarti)--Area-Capacity Data	62
2.2-BN-4	Amarti Dam and Reservoir--Area-Capacity Data	62

15

Number	Title	Follows page
2.0-Fi-14	Area-Capacity Curves--Amarti-Neshe Combined	62
2.0-Fi-7	Profile--Neshe River Damsite	64
2.0-Fi-8	Profile--Amarti River Damsite	64
4.0-BN-87	Neshe River Powerplant--Switching Diagram	64
7.1-Fi-3	Reconnaissance Land Classification and Soil Profiles--Finchaa River Area	80
2.0-Fi-13	Reconnaissance Land Classification and General Plan--Amarti-Neshe Project	80
4.0-BN-169	Map of Ethiopia--Electric Power Load Center--Addis Ababa Complex--Case A	106
4.0-BN-171	Map of Ethiopia--Electric Power Load Centers --Case B	106
4.0-BN-39	Estimated Population Trend--Electric Power Load Analysis	108
4.0-BN-40	Employment--Manufacturing Industries--Electric Power Load Analysis	110
7.2-BN-1	Land Utilization--Blue Nile River Basin	110
4.0-BN-29	Rural Population Density and Distribution--Blue Nile River Basin	110
4.0-BN-30	Gross Industrial Production--Small Industries	116
4.0-BN-31	Gross Industrial Production--Major Industries	116
4.0-BN-32	Total Gross Industrial Production	116
4.0-BN-33	Major Imports--Dollar Value	120
4.0-BN-37	Major Exports--Volume	120
4.0-BN-43	Major Exports--Dollar Value	120
4.0-BN-36	Ethiopia External Trade	120
4.0-BN-35	Building Construction--Addis Ababa	150
4.0-BN-79	Estimated Future per capita Electrical Energy Production Requirements in Ethiopia	156
4.0-BN-151	World Power Data--1961	156
4.0-Et-13	1961 Existing Interconnected System--Addis Ababa Complex	158
4.0-BN-170	Map of Ethiopia--Electric Power Facilities for Addis Ababa Complex, utilizing Finchaa Sub-Basin Powerplants	158

16

Number	Title	Follows page
4.0-Et-4	Daily Load Diagrams--Addis Ababa	160
4.0-Et-5	Load Characteristics--Principal Cities--Ethiopia (Excluding Eritrea)	162
4.0-BN-77	1961-62 Load Characteristics--Monthly Distribution--Interconnected System	162
4.0-BN-78	Future Load Characteristics--Monthly Distribution--Interconnected System	162
4.0-BN-118	Future Load Characteristics--Load Duration and Peak Percent Curves--Heavy Load Conditions--Interconnected System (Excluding Eritrea)	162
4.0-BN-148	Production of Electricity by Industrial Firms	182
4.0-Et-14	1971 Interconnected System--Addis Ababa Complex--Case A or B	186
4.0-Et-15	1980 Interconnected System--Addis Ababa Complex--Case A	188
4.0-BN-172	Estimated Peak Generation Requirements and Schedule of Powerplant Installations --Interconnected System--Case A	188
4.0-BN-173	Estimated Peak Generation Requirements and Schedule of Powerplant Installations --Interconnected System--Case B	188
4.0-BN-85	Alternative Thermal Power at Load Centers--Akaki Steam Plant	190
7.2-Fi-1	Preliminary Farm Layout--Finchaa Project	222
4.0-BN-175	Ethiopian Electric Light and Power Authority --Organization Chart, 1962	226
4.0-BN-176	Phase I Operations--Multiple-Purpose Projects --EELPA and WRD--Organization Chart	226
4.0-BN-177	Phase II Operations--Multiple-Purpose Projects --EP&WRA--Organization Chart	226

17

LIST OF PHOTOGRAPHS

	Follows page
Finchaa River Project--looking south	14
Amarti-Neshe Project--view upstream	44
Finchaa Damsite--looking downstream	46
Finchaa Falls Forebay Damsite--looking upstream	46
Neshe Damsite and Intervalley Basalt--looking upstream	60
Amarti Damsite--looking downstream	62
Neshe Powerplant Site--looking upstream	192

SECTION I - INTRODUCTION

SUMMARY

The Finchaa River Sub-Basin occupies an area of 3,500 square kilometers south of the Blue Nile in Wellegga Province. The Finchaa and its two main tributaries rise in large swamps on the high plateau and drop over a sharp escarpment into the deeply eroded lower Finchaa valley, which contains the lands considered in the development of a multipurpose power and irrigation project in this area. Physically, the project is divided into two parts--the Finchaa and the Amarti-Neshe. The Finchaa would utilize water supply from the Finchaa River, as it emerges from the Chomen Swamp, for power and for irrigation of lands upstream from the area that is drained by the Amarti and Neshe Rivers. The Amarti-Neshe Project would utilize the water from these rivers to develop power and to irrigate lands downstream from those to be irrigated from the Finchaa.

This report is primarily concerned with the Finchaa Project but, because of the proximity of the two projects and the interrelationship of data as collected, both projects are discussed in this volume. Only the Finchaa is discussed in this summary.

The Finchaa Project works would include a storage dam, a power diversion dam, a tunnel and penstocks to carry the water to a powerplant in the lower valley, a diversion dam for irrigation, and canals and laterals to irrigate about 15,000 hectares of land.

Project construction costs are estimated to be as follows.

Finchaa Dam	Eth$ 682,000
Power Diversion Dam	210,000
Tunnel and Penstocks	32,948,000
Powerplant	11,015,000
Transmission Plant	21,004,000
Irrigation Diversion Dam	545,000
Canals, Laterals, and Drains	15,567,000
Access Roads and Service Facilities	4,156,000
Total	Eth$86,127,000

20

The project lands lie at an elevation of about 1500 meters. The soils are well suited to irrigation development and are capable of producing sustained high yields. The topography of the area is lightly rolling with general slopes toward the Finchaa River which flows northward through the center of the wide valley. The soils contain no salts that would be harmful to growing plants, and it is not anticipated that any serious problems in subsurface drainage would develop if irrigation water is properly applied and normal precautions are taken. Excess surface water would be carried away by the existing drainage channels and by drains constructed for this purpose.

The project area, at the present time, is uninhabited and uncultivated, although the highlands on the plateau surrounding the area are populated and extensively farmed. The project lands are covered with low-growing trees, bush, and tall grass that would be removed as the project is developed. Land leveling and clearing costs are estimated to be Eth$5,325,000.

The climate of the project area is typical of this part of Africa with temperatures ranging from 6° C. to 39° C. (43° F. to 102° F.). The days are warm and the nights cool, although frosts do not occur. The rainfall in the area is about 1,000 millimeters annually, with the following general distribution by months.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
17.1	21.3	73.6	69.6	57.1	143.6	229.4	221.7	110.8	37.4	4.5	13.9	1,000.0

During the period from June through September, there is an overabundance of precipitation and the fields become too wet to be properly worked and cultivated by mechanical means. During the remainder of the year, the precipitation is not sufficient to meet the requirements for full crop production. To offset the normal shortages of rainfall, 954 millimeters of irrigation water would be required.

Under existing conditions in Ethiopia, farming operations are limited to an area that the farmer can cultivate with the tools and equipment available to him within his slender financial resources. It is recognized that, because of the lack of storage and transportation facilities, there is little current market for farm products in excess of requirements for family consumption and small amounts exchanged locally. This results in farms of about three or four hectares in area and a standard of subsistence lower than is desirable. The average annual farm income is estimated to be about Eth$170 to Eth$300. The primary objective of the IEG in the development of her resources is an improvement of the standard of living

of her people and an improvement in the national economy by increasing production. The project has been designed to provide modern farms of about 17 hectares in area, each capable of producing more food for family consumption, improving housing, providing opportunity for education of children, and permitting the farmer to acquire an equity in the land and set aside a small savings for emergencies and old age.

Farm products in excess of requirements of the farm family would be marketed to help support the increasing population with perhaps some products available for export to world markets.

During the period of initial development, a training program would be necessary to acquaint the farmers and the operators of the irrigation system with modern practices and equipment. The project at ultimate development would include approximately 880 individual farms. It is anticipated that many of the farmers would come from the agricultural college and schools. Few of the farmers will have the financial resources required to meet initial costs. Therefore, it will be necessary for initial capital to be made available to them.

The project can produce a wide variety of crops suitable to the climate and growing conditions. However, in order to present a more conservative view for the purpose of the economic analysis of the project, crops projected were mostly those commonly produced in Ethiopia and widely accepted in the Ethiopian diet. A few new crops were included for the export market and for gradual introduction into the Ethiopian diet and economy.

The annual value of crops produced is estimated to be about Eth$8,932,000. Since there is no production from the area at the present time, this amount is considered as the gross agricultural benefit resulting from the development of the project. Many intangible benefits will result, but no attempt has been made to place a monetary value on these.

The project will provide 880 new, independent farms with a stable population of about 4,000 persons in the farm families. In addition, it is estimated that a labor force of 13,000 persons would be required, or 61,000 people including families. Thus, about 65,000 persons would be supported directly by the agricultural sector of the project.

The Finchaa hydroelectric power facilities would have an installed generating capacity of 80,000 kw. and would produce 360,420,000 gross kw.-hr. annually to meet the expanding power requirements of the Interconnected System with loads centered mainly

22

at Addis Ababa. Power for the area is now produced by the Ethiopian Electric Light and Power Authority at plants on the Awash River. Two additional plants are planned by EELPA on the Awash, but even with these plants additional power will be required in 1971, either from a fourth Awash plant or from the Finchaa Project.

The powerplant would include two impulse-type turbines operating under a net head of 467 meters. A 250-kilometer, 161-kv. transmission line would be required to deliver power to the load centers and would tie into the existing EELPA facilities, thus forming an interconnected system.

It is assumed that initially the powerplant would be operated and the power marketed by the existing EELPA organization in cooperation with the Water Resources Department.

There is an adequate water supply for power and irrigation developments.

Benefit-Cost Comparison

Annual estimated irrigation benefits	Eth$ 8,936,000
Annual cost allocated to irrigation	2,006,000

$$\frac{8,936,000}{2,006,000} = 4.45 \text{ to } 1.00, \text{ benefit to cost ratio}$$

Annual estimated power benefits	Eth$16,400,000
Annual cost allocated to power	5,367,000

$$\frac{16,400,000}{5,367,000} = 3.06 \text{ to } 1.00, \text{ benefit to cost ratio}$$

Total annual benefits	Eth$25,336,000
Total annual cost	7,373,000

$$\frac{25,336,000}{7,373,000} = 3.44 \text{ to } 1.00, \text{ benefit to cost ratio}$$

The investigation covered by this report must be considered as a limited reconnaissance lacking the detail that would be required for the development of a definite plan upon which a project could be constructed, but adequate for the general plan and evaluation and for its intended purpose of assisting the Imperial Ethiopian Government in the selection of projects worthy of further detailed investigation.

It is recommended that the Imperial Ethiopian Government proceed with a further detailed study of the project.

CONCLUSIONS

1. The climate in the project areas is subtropical and well suited to the production of many crops and to the production of more than one crop each year.

2. The soils are generally deep, friable, permeable, medium to fine textured latosols, and are well suited to irrigation--particularly when properly fertilized.

3. Land slopes are slightly excessive for optimum irrigation conditions and the slopes of the lands are the principal reasons for downgrading land.

4. The moderately dense forest cover will need to be removed prior to irrigation, but the resulting wood should be useful for charcoal and firewood.

5. Construction of project irrigation works will be quite expensive because of the many drainage crossings needed.

6. Erosion hazards are fairly high and considerable care must be used in irrigation application and water disposal to maintain a permanent irrigated agriculture.

7. Regardless of the extent of system interconnections that would be possible by the year 1980, the Finchaa power facilities are required to be in service during the year 1974. The Neshe power facilities will be required in 1977 or 1978, with the output of both powerplants plus the four Awash plants providing for the needs of the Interconnected System through 1980 or 1981.

The Finchaa and Neshe projects are multipurpose, but the potential hydroelectric power facilities are such that they can be developed in advance and independently of the irrigation facilities without being prejudicial to the interests of the irrigation features of the project. Hydroelectric powerplant requirements determine the maximum capacity of the water storage facilities and waterways so that advance construction of the hydroelectric facilities would not affect the later construction of the separate irrigation facilities downstream. If this is contemplated, the multiple-purpose nature of the projects must not be lost sight of, and a part of the income from power revenues should be set aside for complete project development whenever that might occur.

8. The Finchaa Project is attractive in another respect in that another electrically identical powerplant (Neshe) can be constructed nearby with both powerplants connected to the Addis Ababa Complex by a

24

single, steel tower, transmission line carrying two circuits, or by a higher voltage line carrying only one circuit. (See SECTION V.)

9. The sites are geologically suitable for the proposed dams, powerplants, and appurtenant structures.

RECOMMENDATIONS

1. A detailed land classification study should be made prior to construction. Among other things, this study should (1) delineate the topographic variables accurately; (2) determine the needs for subsurface drainage construction; (3) separate and appraise productivity potentials for the various types of soils; (4) ascertain a more exact cost of tree and brush clearing and land leveling; (5) study the erosiveness of the soils and determine the need for and cost of erosion control; (6) determine the type and quantity of fertilizer or soil amendments needed for maximum production; and (7) determine the method of irrigation best suited to the land and people.

2. An experimental farm should be established early in the development period to determine the best crops and agricultural practices to use.

3. Future studies should include a study of the anticipated irrigation water quality and the effects that such water will have on the project soils.

4. Any initial irrigation development should avoid developing the bottoms or lower side slopes of any deep drainageways because of the danger that these areas will become waterlogged when the adjacent higher lands are irrigated.

5. During preconstruction investigations the foundations for dams and other structures should be explored by a core drilling program to establish the depths to and the permeability of the intervalley volcanic material. Potential borrow areas should be sampled and analyzed, and detailed geologic maps prepared for all of the structure sites.

6. Awash No. 4 should not be constructed following Awash No. 3, if at all possible; and, with this in mind, every effort should be made to expedite the engineering and economic feasibility studies for the Finchaa Project with the objective of having the power facilities in operation by the end of 1971 instead of during 1974. By that time, enough operating experience with the Koka reservoir and Awash River should have been accumulated to determine

25

whether Awash No. 4 should be constructed. If construction of Awash No. 4 is justified, this could be done after the Finchaa or Neshe project development, because by then the hydroelectric powerplants will not all be in one river basin.

7. Compilation of hydrological data must be expanded and continue uninterruptedly on the Finchaa, Neshe, and Amarti Rivers to provide firmer data upon which to base final project plans.

8. It is recommended that topographic surveys be performed to about a 1-meter contour interval on the project area, and about a 5-meter interval on the drainage area. Construction materials should be further investigated and ascertained. The construction cost estimates, especially as they apply to unit prices, should further be refined.

9. Malaria and the tsetse fly are a hazard to the project and control measures should be introduced prior to project development. Agricultural and economic studies should be further expanded and continued.

26

SECTION II - GENERAL DESCRIPTION

Basin Description

The Finchaa River Sub-Basin is located in the south central portion of the Blue Nile River Basin. It is bounded on the south by the Great Gibe River Basin, on the north by the Abbay (Blue Nile) River, on the west by the Diddessa Sub-Basin, and on the east by the Guder drainage area. Roughly resembling an arrowhead in shape, the subbasin is distinguished by the Chomen Swamp, a vast flat area lying on the plateau between the mountains and a precipitous escarpment. Situated at an elevation of 2210 meters (7250 feet) above sea level, the Chomen Swamp is fed by numerous small streams which head in the high hills (highest of which is at an elevation of 3000 meters or 9840 feet above sea level) and emerge at the northeastern end of the swamp as the Finchaa River. The gradient throughout the swamp is so flat that drainage systems are not well established, and during the rainy season and for a long period after the rains have ended, the area is essentially a large, shallow lake containing water grass, papyrus, reeds, and other water vegetation. Above the swamp, the slopes and rounded ridges are cultivated for raising grain crops.

From the outlet, the Finchaa River meanders generally in an easterly direction for about five kilometers, where, at the brink of the plateau, it plunges over an escarpment in two prominent waterfalls, falling some 500 meters (1,640 feet) in two kilometers. Below the falls, the water then cascades for several kilometers through a steep canyon. Downstream from the steep canyon section, the stream gradient again flattens and the valley widens. Along the sides of this reach of the river gentle slopes are covered with deep soil, which potentially could be developed into an irrigation project. These slopes are covered with very tall grass and scattered trees and brush. Few, if any, people live in this area, perhaps because it is infested with tsetse flies and mosquitoes. There is only one important tributary to the Finchaa River--the Neshe, having its headwaters to the west of the lower valley. The Amarti River, a tributary of the Neshe, and the Neshe River drain an area composed typically of high mountains, steep slopes, and rough topography. The two rivers flow into long, narrow valleys with a slight gradient, forming narrow swampy areas, and then drop over the edge of the

escarpment to form the Neshe River, which in turn flows into the Finchaa near its confluence with the Blue Nile.

Projects Area Description

The area under consideration is the lower valley, bounded on the southwest and the east by a sandstone escarpment (in places, lava capped), on the north by rough breaks along the Blue Nile River canyon, and on the west in the lower portion of the valley by a low saddle forming a divide between the Finchaa Project area and the Amarti-Neshe Project area. It is situated about 1500 meters above sea level (500 meters below the escarpment) and is about 12 kilometers (7.5 miles) wide and 37 kilometers (23 miles) in length. The valley is fairly well covered with dense growth of tropical savannah woodland, interspersed with a very dense growth of tall grass. The stream bottoms of the tributaries support a dense growth of tall trees, which reach a height of 30 meters (100 feet). Shrubs and bushes are interspersed throughout the bottoms. The valley is uninhabited and uncultivated, probably due to the heat and the unfavorable health conditions, as tsetse flies were observed and undoubtedly malaria is prevalent.

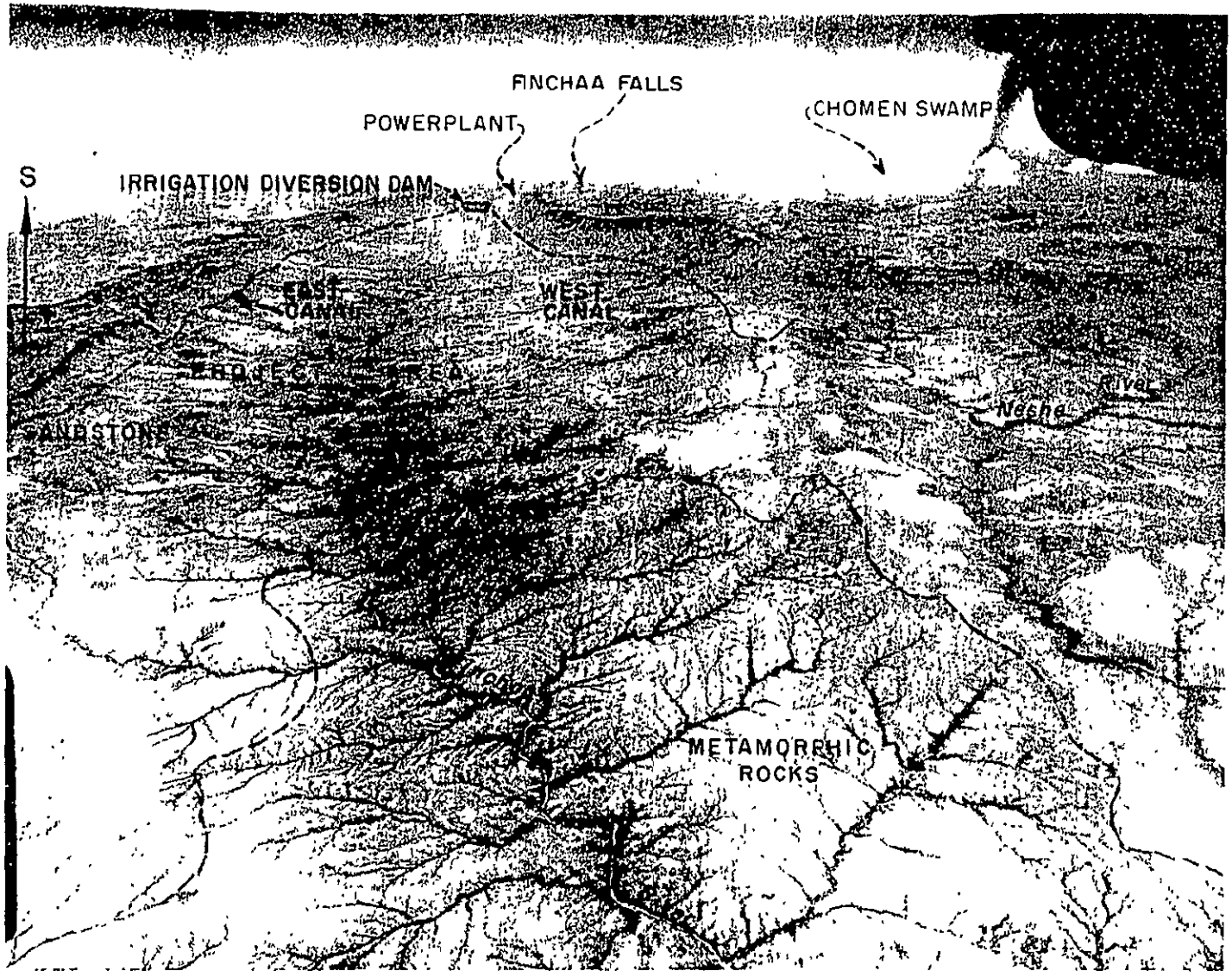
The Finchaa River bisects the valley, and its many tributaries generally approach and enter the main stream at right angles to the south-north direction of the river's flow. The tributaries are entrenched from three to ten meters into the valley soil. These channels do not have precipitous side slopes as a rule but tend toward somewhat rolling topography. The higher lying land areas are fairly large, about 700 hectares (1,700 acres), and the streams provide adequate outlets for surface runoff. The slopes on these areas are usually quite gentle and smooth in surface relief. Steep slopes and dissected rough lands occur at the head of the valley where the escarpment forms a canyon.

Population

The Finchaa valley is uncultivated and uninhabited, but evidence of former cultivation is present. The climate is somewhat warmer than most highland Ethiopians prefer, but the area apparently was abandoned because of the historic memory and fear of potential recurrence of human and animal disease. The presence of such inimical insects as the Anopheles malarial mosquito and the tsetse fly, which can transmit encephalitis or sleeping sickness, keep the valley empty of human habitation. Some paths and many game trails exist in the area, but there are no roads or buildings.

Present Economy

At present, the lower valley of the Finchaa, Amarti, and Neshe Rivers may be said to have no economy. The area is unpopulated;



FINCHAA RIVER PROJECT—LOOKING SOUTH

it is neither farmed or grazed on a permanent or shifting basis; no important amount of wild products is gathered; and the amount of hunting, fishing, and trapping is negligible.

Climate

The climate in the lower valley, where the project development is contemplated, is warm and subtropical, favorable to the raising of a wide variety of crops, including such subtropical types as oil seeds, cereal crops, and coffee. Average annual precipitation is uncertain, but is estimated at 100 centimeters, the bulk falling in the rainy season--July through September. The average annual temperature will be about 22° Centigrade (72° Fahrenheit). Although frost is not expected, autumn nights tend to be cool, and strictly tropical crops probably will not do well. On the other hand, the lack of frost precludes raising those temperate deciduous crops that require freezing temperatures for dormancy.

Table II-1 shows averages of July and January and annual records for temperature and precipitation at 16 stations in the Blue Nile Basin. Most of these stations are in the upland, more inhabited area, and none lies below the escarpment in the Finchaa Basin. Inspection of Tables II-2, II-3, and II-4, which show monthly averages of temperature and monthly totals of precipitation at Ambo over the 1951 through 1961 period, may afford a basis for estimating how weather varies on the potential service area. It is recommended that a climatological station be established immediately in the Finchaa area and that applicable records be taken regularly.

By referring to climatic data, farm delivery requirement on the potential service area has been estimated as shown in Table III-2. To these farm-delivery requirements, 20 percent has been added to allow for operational waste, and seepage losses were also provided for as mentioned within narratives for the Finchaa and the Amarti-Neshe project descriptions.

Quality of Water

Quality-of-water samples were taken throughout the annual fluctuation of flow at several widely spaced locations in the Blue Nile Basin. They all show good to excellent quality for irrigation purposes, primarily because most of the bedrock in the upland area is basic, igneous material which does not produce deleterious amounts of salt, and also because the steep, fine grained, soil mantle produces high percentages of surface runoff, so that there is a minimum exposure of subsurface flow to rocks which could produce significant amounts of dissolved salts in the total flow. Both the Finchaa and the Amarti-Neshe Projects fit this general description, and it is

therefore predictable that a more detailed sampling program would show the flows to be of good or excellent chemical quality for irrigation.

TABLE II-1

CLIMATIC STATIONS IN OR NEAR ABBAY BASIN IN ETHIOPIA

Station	Elevation in Meters	Temperature in degrees centigrade Average of daily maxima		daily minima		Precipitation in millimeters Average for		
		Jan.	July	Jan.	July	Jan.	July	Year
Addis Ababa	2, 408	24	20	6.9	10.2	21.9	252.0	1, 142.5
Ambo Ag. Col.	2, 130	27	22	10.9	12.0	18.4	246.8	1, 075.3
Arjo	2, 565	-	-	-	-	13.8	321.8	1, 756.4
Asosa	1, 665a/	31	23	14.0	14.8	0	281.6	1, 253.0
Bahir Dar	1, 802	26	24	8.9	13.4	0	309.2	1, 051.8
Dangila	2, 107a/	29	26	3.3	9.9	0.8	359.2	1, 468.9
Debre Birhan	2, 840	21	21	8.7	11.5	20.5	323.0	925.2
Debre Markos	2, 313	24	18	7.4	9.8	20.8	331.0	1, 416.3
Debre Tabor	2, 945	26	23	5.8	8.0	7.2	518.3	1, 714.9
Fiche	2, 820	19	15	7.8	8.9	11.9	497.3	1, 398.4
Galabat	765	-	-	-	-	0	199.9	877.8
Gimbi	1, 988a/	30	24	16.4	11.8	22.9	336.5	2, 151.9
Gondar	2, 121	28	21	10.0	13.2	3.1	319.2	1, 213.0
Jima Ag. Col.	1, 701a/	27	21	9.9	13.4	33.8	214.2	1, 551.0
Kembolcha	1, 903	24	26	10.0	13.7	31.3	295.6	1, 104.2
Lekkemt	2, 005	24	20	10.8	10.4	16.2	368.8	2, 028.6
Mendi	1, 767a/	26	22	12.9	13.8	7.8	296.3	1, 763.1
Nejo	1, 900	27	20	13.3	13.3	2.9	321.4	1, 892.0

a/Elevation from C & GS benchmark; not identical with station.

32

TABLE II-2

TEMPERATURE AT AMBO AGRICULTURAL SCHOOL IN DEGREES CENTIGRADE

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL	Percent MEAN
						Average of Daily Minima								
1954	9.3	12.7	13.4	12.9	12.3	11.8	11.9	11.7	10.9	10.0	9.9	10.0	136.8	11.4
1955	11.9	10.8	11.6	13.0	11.8	11.3	11.8	11.2	11.6	10.4	10.4	11.1	137.9	11.5
1956	10.9	11.1	13.5	13.5	11.8	11.3	12.1	11.9	11.5	11.3	8.8	9.5	137.2	11.4
1957	9.8	11.4	12.2	12.5	12.0	10.7	11.6	11.7	11.0	11.5	11.9	11.1	137.4	11.5
1958	13.2	10.0	13.4	13.5		12.4	13.0	12.5	12.4	10.0				
1959	12.1		12.8	12.9	12.5	11.3	12.3	12.2	11.4	11.3	9.6	10.1		
1960	10.0	11.8	11.9	11.7	11.9	10.7	11.6	11.8	10.2	10.5	9.4			
1961	10.0	11.5	12.0	11.5	10.0									
Total	87.2	79.3	100.8	101.5	82.3	79.5	84.3	84.0	79.0	75.0	60.0	51.8		
Average	10.9	11.3	12.6	12.7	11.8	11.4	12.0	12.0	11.3	10.7	10.0	10.4	137.1	11.4

TABLE II-3

TEMPERATURE AT AMBO AGRICULTURAL SCHOOL IN DEGREES CENTIGRADE
Elevation 2,130 meters

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG	SEPT	OCT.	NOV	DEC	TOTAL	Percent MEAN
						Average Daily Temperature								
1954	18.0	20.3	20.4	20.5	19.8	17.6	16.8	16.7	16.5	17.2	17.6	17.9	219 3	18.3
1955	18.8	19.5	20.3	20.2	19.4	17.7	16.5	16.7	17.1	17.6	17.8	18.0	219 6	18.3
1956	18.3	19.5	21.1	19.9	19.2	17.4	16.4	16.5	17.3	17.1	16.2	17.5	216.4	18.0
1957	18.8	18.8	18.2	19.2	19.2	17.8	16.8	16.7	17.6	19.2	19.5	18.9	220.7	18.4
1958	20.1	18.5	21.2	20.9					19.2	18.9				
1959	20.6													
1960	18.4	19.8	19.9	20.3	19.2	17.6	16.9	17.1	16.3	18.2	18.2			
1961	18.3	19.2	19.8	18.8	19.4									
Total	151.3	135.6	140.9	139.8	116.2	88.1	83.4	83.7	104.0	108.2	89.3	72.3	1,312.8	
Average	18.9	19.4	20.1	20.0	19.4	17.6	16.7	16.7	17.3	18 0	17 9	18.1	220.1	18.4
						Average of Daily Maxima								
1954	26.7	27.9	27.4	28.1	27.3	23.3	21.7	21.6	22.1	24.3	25.2	25.8	301.4	25.1
1955	25.6	28.2	28.9	27.4	27.0	24.1	21.2	21.2	22.5	24.8	25.2	24.8	300.9	25.1
1956	25.6	27.8	28.7	26.2	26.5	23.4	20.6	21.1	23.1	22.9	23.5	25.4	294.8	24.6
1957	27.7	26.2	24.1	25.8	26.3	24.8	21.9	21.7	24.2	26.9	27.0	26.7	303.3	25.3
1958	27.0	26.9	29.0	28.3					26.0	27.7	27.6	27.5		
1959	29.0	30.1												
1960		27.7	21.9		26.5	24.4	22.2	22.3	22.4					
1961	26.5	26.9	27.5	26.0	28.8									
Total	188.1	221.7	187.5	161.8	162.4	120.0	107.6	107.9	140.3	126.6	128.5	130.2		
Average	26.9	27.7	26.8	27.0	27.1	24.0	21.5	21.6	23.4	25.3	25.7	26.0	303.0	25.3

24

TABLE II-4

PRECIPITATION IN MILLIMETERS AT AMBO AGRICULTURAL SCHOOL

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
1951	0.0	52.0	109.0	42.5	72.0	200.5	200.0	199.0	107.0	48.0	2.0	31.0	1,063.0
1952	0.0	15.0	40.5	116.0	64.0	129.3	211.2						576.0
1954	0.0	12.5	79.4	51.0	33.4	141.7	241.1	245.4	152.9	19.5	1.0	3.5	981.4
1955	60.9	4.9	25.3	66.7	44.0	174.7	352.6	229.7	148.0	17.2	3.1	8.8	1,135.9
1956	11.2	8.9	43.4	92.5	66.5	161.2	173.7	286.2	125.1	158.8	2.2	7.4	1,137.1
1957	0.6	46.6	196.3	101.9	99.9	99.1	315.3	185.2	82.2	0.0	0.8	8.5	1,136.4
1958	49.5	0.0	109.4	101.2	19.3	195.8	245.4	187.3	74.3	29.6	0.0	33.0	1,044.8
1959	58.0	21.9	40.5	46.4	78.9	119.8	231.8	304.2	122.8	47.7	29.7	18.5	1,120.2
1960	4.1	60.4	62.8	90.9	106.4	167.9	250.4	271.1	140.6	1.1	0.0	8.3	1,164.0
1961	0.1	6.9	84.3	38.5	30.1								159.9
Total	184.4	229.1	790.9	747.6	614.5	1,390.0	2,221.5	1,908.1	952.9	321.9	38.8	119.0	9,518.7
Average	18.4	22.9	79.1	74.8	61.4	154.4	246.8	238.5	119.1	40.2	4.8	14.9	1,075.3
1962	No record												

35

SECTION III - HYDROLOGY

FINCHAA PROJECT

Operation Study

Finchaa Dam would be constructed on the Finchaa River at the Chomen Swamp outflow point, and power would be developed at the falls between the reservoir and the service area. During the irrigation season, intervening tributaries would produce no divertible flow. The principal hydrographic problem is whether a loss or a gain in consumption will result from providing a reservoir where there is now a swamp. Rain falling on a water surface would ordinarily be expected to yield a higher percentage of runoff than rain falling on land. However, the fact that records of the Finchaa and Abbay below Tana show relatively low yields per unit of drainage area suggests that present consumption is much greater on lake and swamp surfaces than for the land area (see Dwg. No. 6.0-BN-27). The Dabus may also be considered to have a low yield. Dabus is in the highest rainfall belt and would fall well above the curve, if swamp losses did not pull the yield down to normal.

The boundary of Chomen Swamp recedes as the dry season progresses, and there may be 30 or 40 centimeters of soil moisture lost to evaporation and transpiration after the surface is unwatered. On most of the lake, grass or fronds extend through the water, even in September when content reaches maximum; and rainy season consumption is probably as great as, or greater than, it would be on a lake of the same area. In fact, grass may be expected to extend to much of the lake surface, even after a reservoir is constructed. But there will be some area where the water is too deep for grass to survive during the period of maximum content, and consumption in this area may decline as a consequence of building the reservoir. Not knowing what the net effect of all these factors will be, the operation study was made on the assumption that future annual consumption with a reservoir would equal past annual consumption without a reservoir.

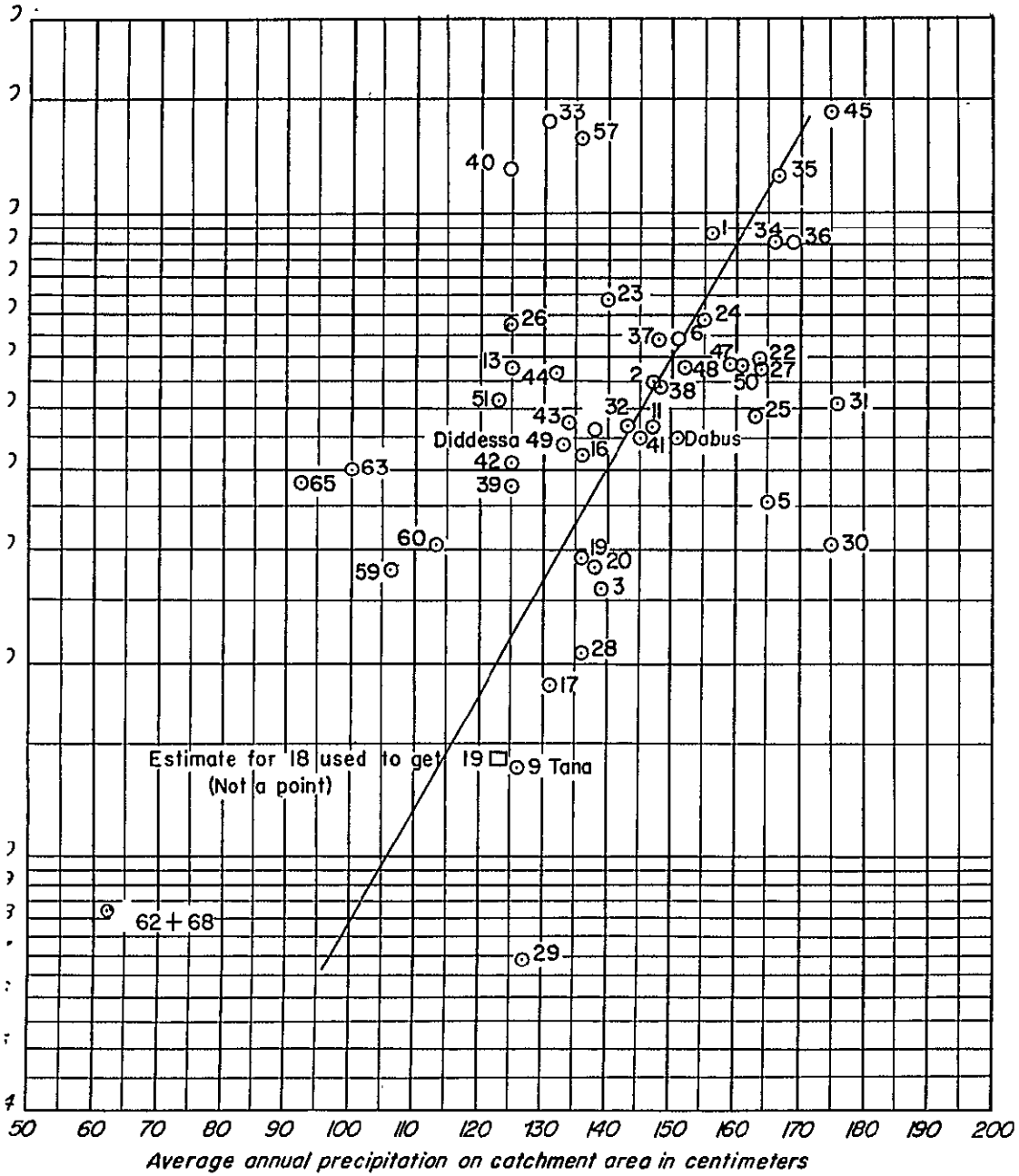
Estimate of Available Flow

There are four years of record at the damsite. Flow available during other years was estimated by a monthly correlation with the record of the Abbay River at Kese. A correlation made directly with the Abbay at Roseires record might have been preferable, but concurrent records were unavailable when the operation study was initiated. Because of regulation by the swamp, the Finchaa River probably should have been shown to yield lesser flows in relation to Abbay flows, when monthly Abbay flows exceed six billion cubic meters. However, the difficulties of estimating losses in the swamp made it appear improbable that any considerable refinement could be secured. There is no question that the facilities as outlined will serve the 15,000-hectare Finchaa Project service area without shortage, and power yields during most periods will equal those shown in the study. If, after further study or with operating experience, it becomes apparent that a drought period could impair power production, additional water may be imported to maintain the yield. A canal above the escarpment, one or two kilometers in length, would be adequate for diverting Kontor Creek into Chomen Swamp at approximate longitude 37°20' E, latitude 9°10' N. Also, the Amarti-Neshe Project studies show that the Neshe River will produce more flow than is required on that service area. Should additional records show Finchaa flow short and Neshe in surplus, the boundary between their service areas can be shifted southward.

Some additional yield could be secured by providing dug channels at the swamp inlets. However, if this is attempted, it should be done with caution. Perhaps one inlet could be canalized; then, after ten or twenty years, if the net result appeared advantageous, others could be canalized. The swamp appears to be on slopes adequate to maintain velocities of perhaps one meter per second in a channel. Many of the inlets have channels extending for some distance into the swamp; and, at the lower elevations, there are channels through the swamp in which velocities at times of maximum content appear to reach about one meter per second. Although the swamp is on a grade, velocity over its remainder is retarded by the grass. Possible effects of connecting each inlet channel with the main outlet channel would be reduction in consumption by grass and evaporation around the upper edges of the proposed reservoir; transportation of silt, which might otherwise be deposited in grass above the high water line, into the reservoir; minor amounts of erosion in and near the upper ends of the channels; less natural irrigation and therefore lesser volume growth of grass near the edges of the swamp; and a change, perhaps for the better, in species and quality of grass in such areas.

Area-Capacity Relationships

The area-capacity curve (Dwg. No. 2.0-Fi-1) is based upon a minimum of data. The Finchaa Reservoir operation study (Table III-1)



NOTES

Reasons for dispersion of points:

1. *Errors in rainfall data and their interpretation on map.*
2. *Areas of smaller drainage basins are known only to ± 50 percent.*
3. *Average annual flows are estimated from less than one year of record in some instances. Average record is about 1.5 years.*
4. *More Oct. to May rainfall in south-west produces higher percentage use there.*

REVISED MAY 2, 1963

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., A I D AND U.S. DEPT. OF INT., BUR. OF RECL.

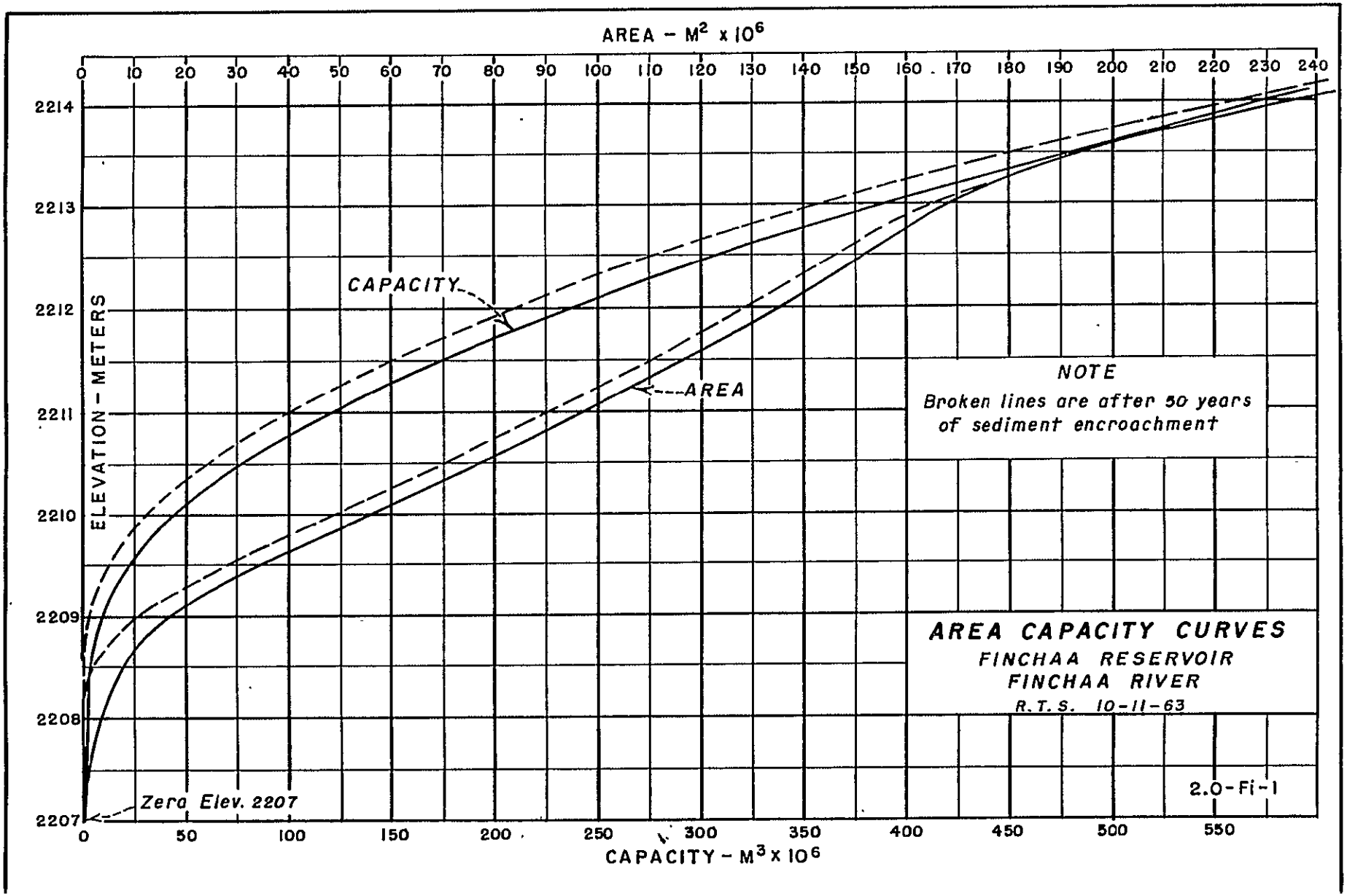
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

RAINFALL—RUNOFF RELATIONSHIP IN BLUE NILE BASIN

DRAWN KRAMER SUBMITTED Kramer
TRACED A. N. MUSSA RECOMMENDED Barnes
CHECKED Admasu M. APPROVED R. Bundick

Addis Ababa Ethiopia MAR 13, 1965 | 6.0-BN-27


AREA - M² x 10⁶
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240
ELEVATION - METERS
2214
2213
2212
2211
2210
2209
2208
2207
CAPACITY
AREA
Zero Elev. 2207
0 50 100 150 200 250 300 350 400 450 500 550
CAPACITY - M³ x 10⁶
NOTE
Broken lines are after 50 years of sediment encroachment
AREA CAPACITY CURVES
FINCHAA RESERVOIR
FINCHAA RIVER
R.T.S. 10-11-63
2.0-Fi-1

was made with a maximum content of 414.42 million cubic meters and a minimum content of 33.00 million cubic meters, or active capacity was 381.42 million cubic meters. Subsequently, plans for the dam (Dwg. No. OA-23-101) were laid out showing distribution of sediment expected during the first fifty years of operation, and capacities after 50 years of operation. The spillway crest was set at elevation 2213.4 (capacity at 50 years, 431.3 million cubic meters), and the minimum operation level required to serve the project needs was put at elevation 2210.0 (capacity at fifty years, 31.2 million cubic meters). Thus, with this dam, active capacity after fifty years of sedimentation is estimated as 400.1 million cubic meters (slightly greater than the 381.42 million cubic meters requirement shown by the operation study). After 100 years, the elevation of sediment at the dam is expected to be 2208.85 meters.

Monthly Power Releases

Releases were made in the operation study to produce power under a level load curve. This release was just adequate to meet irrigation requirements in the month of December with an excess in all other months. The average effective head is 467 meters after allowing for average friction losses, and generation is 361 million kilowatt-hours yearly after allowing for an 80 percent average turbine-generator efficiency.

Irrigated Area

Estimated farm delivery requirement, as shown in Table III-2, is 0.954 meter (3.13 feet). Allowing 12 percent for canal seepage and 20 percent for operational waste, the operation study shows that, if the reservoir is constructed to the estimated dimensions, 15,000 hectares (37,064 acres) of land can be irrigated with no shortages.

Spillway Design Flood

Ordinates of the maximum probable inflow flood are shown on Table III-3.

Flood Frequency

Frequency of floods to be anticipated during construction is shown on Table III-4.

Outlet Capacity

Table III-1 shows a minimum content in July 1914, when required release would have been 30.61 million cubic meters. The forebay at the head of the penstock is adequate for peaking; and outlet capacity should therefore be 11.4 cubic meters per second with water surface at the minimum operating level of 2210 meters, which is required to clear the 100-year sediment level and discharge 11.4 cubic meters per second.

AMARTI-NESHE PROJECT

Operation Study

Amarti yield will be diverted through a cut having an invert elevation of 2229 meters to the Neshe reservoir and outlet. Neshe floods will be diverted through the same cross channel to the Amarti spillway.

As shown in the operation study, Table III-5, minimum content is 165 million cubic meters and maximum is 751 million, and the required active content after 50 years of sedimentation and above the minimum operating level is 586 million cubic meters (475,000 acre-feet).

Estimate of Available Flow

On the basis of four current-meter measurements made on each stream in 1962, flows of the two streams have been estimated to total the amounts shown in column 2 of Table III-5. Gages have since been established. Several years of record will be necessary to prepare an operation study adequate for use in final, detailed plans.

Area-Capacity Relationships

The combined area-capacity table for the two reservoirs as anticipated after 50 years of sedimentation is shown on Table III-6, sheet 5. Assuming a cross-channel invert elevation of 2229 meters, each capacity item in this table includes 8.1 million cubic meters of inactive content in Amarti reservoir below elevation 2229.

After 100 years of operation, sediment at Neshe dam is expected to have a surface elevation of 2184.3 meters (7166 feet).

Elevation of sediment at Amarti dam and at the cross channel after 100 years of operation is expected to be 2228.6 meters (7312 feet).

Monthly Power Releases

Canal water surface immediately above the penstock is expected to be 2205 meters. Jet nozzle elevation for the power release is estimated as 1625 meters. Average effective head is estimated to be 560 meters after allowing for an average penstock loss of 20 meters.

4

TABLE III-1 Sheet 1 of 3

RESERVOIR OPERATION STUDY

FINCHAA RESERVOIR FINCHAA RIVER

Min STORAGE	Max ELEVATION	Max STORAGE	
33,000,000 cu m (26,756 ac-ft)	2,213.13 m (7,261 ft)	414,420,000 cu m (335,970 ac-ft)	Net power head = 467 m 360,480,000 kw-hr per yr at 80% eff.

FIRM YIELD 210,450,000 cu m per yr (irrig) 15,000 hectares
Max 354,250,000 cu m per yr (power) (37,100 acres)

Year	Months	Required power release	Power generation kw-hr x 10	Inflow	Irrigation release	Additional release for power	Spill	Change in storage	End of month reservoir storage
		1	2	3	4	5	6	7	8
									414.42
1911	Oct.	30.08	30.61	99.00	20.81	9.27	68.92	0	414.42
	Nov.	29.14	29.65	54.70	28.24	0.90	25.56	0	414.42
	Dec.	30.08	30.61	29.50	30.08	0	0	-0.58	413.84
1912	Jan.	30.08	30.61	15.30	29.99	0.09	0	-14.78	399.06
	Feb.	28.14	28.63	8.80	26.99	1.15	0	-19.34	379.72
	Mar.	30.08	30.61	5.20	24.87	5.21	0	-24.88	354.84
	Apr.	29.14	29.65	4.00	25.64	3.50	0	-25.14	329.70
	May	30.08	30.61	2.90	23.83	6.25	0	-27.18	302.52
	June	29.14	29.65	2.50	0	29.14	0	-26.64	275.88
	July	30.08	30.61	13.90	0	30.08	0	-16.18	259.70
	Aug.	30.08	30.61	50.70	0	30.08	0	+20.62	280.32
	Sept.	29.14	29.65	102.00	0	29.14	0	+72.86	353.18
TOTALS		355.26	361.50	388.50	210.45	144.81	94.48	-61.24	-
1912	Oct.	30.08	30.61	70.00	20.81	9.27	0	+39.92	393.10
	Nov.	29.14	29.65	31.00	28.24	0.90	0	+1.86	394.96
	Dec.	30.08	30.61	15.30	30.08	0	0	-14.78	380.18
1913	Jan.	30.08	30.61	9.00	29.99	0.09	0	-21.08	359.10
	Feb.	27.13	27.61	5.20	26.99	0.14	0	-21.93	337.17
	Mar.	30.08	30.61	4.00	24.87	5.21	0	-26.08	311.09
	Apr.	29.14	29.65	3.80	25.64	3.50	0	-25.34	285.75
	May	30.08	30.61	3.00	23.83	6.25	0	-27.08	258.67
	June	29.14	29.65	5.80	0	29.14	0	-23.34	235.33
	July	30.08	30.61	4.30	0	30.08	0	-25.78	209.55
	Aug.	30.08	30.61	21.90	0	30.08	0	-8.18	201.37
	Sept.	29.14	29.65	55.50	0	29.14	0	+26.36	227.73
TOTALS		354.25	360.42	228.80	210.45	143.80	0	-125.45	-

Sept. 1962

42

Year	Months	Required power release	Power generation kw-hr x 106	Inflow	Irrigation release	Additional release for power	Spill	Change in storage	End of month reservoir storage
		1	2	3	4	5	6	7	8
									227.73
1913	Oct.	30.08	30.61	52.00	20.81	9.27	0	+21.92	249.65
	Nov.	29.14	29.65	20.00	28.24	0.90	0	-9.14	240.51
	Dec.	30.08	30.61	7.00	30.08	0	0	-23.08	217.43
1914	Jan.	30.08	30.61	3.90	29.99	0.09	0	-26.18	191.25
	Feb.	27.13	27.61	2.30	26.99	0.14	0	-24.83	166.42
	Mar.	30.08	30.61	2.10	24.87	5.21	0	-27.98	138.44
	Apr.	29.14	29.65	2.30	25.64	3.50	0	-26.84	111.60
	May	30.08	30.61	2.40	23.83	6.25	0	-27.68	83.92
	June	29.14	29.65	2.30	0	29.14	0	-26.84	57.08
	July	30.08	30.61	6.00	0	30.08	0	-24.08	33.00
	Aug.	30.08	30.61	49.00		30.08	0	+18.92	51.92
	Sept.	29.14	29.65	128.00	0	29.14	0	+98.86	150.78
TOTALS		354.25	360.48	277.30	210.45	143.45	0	-76.95	-

1914	Oct.	30.08	30.61	85.30	20.81	9.27	0	+55.22	206.00
	Nov.	29.14	29.65	71.00	28.24	0.90	0	+41.86	247.86
	Dec.	30.08	30.61	40.90	30.08	0	0	+10.82	258.68
1915	Jan.	30.08	30.61	16.30	29.99	0.09	0	-13.78	244.90
	Feb.	27.13	27.61	9.00	26.99	0.14	0	-18.13	226.77
	Mar.	30.08	30.61	5.00	24.87	5.21	0	-25.08	201.69
	Apr.	29.14	29.65	4.00	25.64	3.50	0	-25.14	176.55
	May	30.08	30.61	2.40	23.83	6.25	0	-27.68	148.87
	June	29.14	29.65	5.20	0	29.14	0	-23.94	124.93
	July	30.08	30.61	12.00	0	30.08	0	-18.08	106.85
	Aug.	30.08	30.61	32.30	0	30.08	0	+2.22	109.07
	Sept.	29.14	29.65	66.30	0	29.14	0	+37.16	146.23
TOTALS		354.25	360.48	349.70	210.45	143.80	0	-4.55	-

Sept. 1962

Year	Months	Required power release	Power generation kw-hr x 10^6	Inflow	Irrigation release	Additional release for power	Spill	Change in storage	End of month reservoir storage
		1	2	3	4	5	6	7	8
									146.23
1915	Oct.	30.08	30.61	84.00	20.81	9.27	0	+53.92	200.15
	Nov.	29.14	29.65	57.50	28.24	0.90	0	+28.36	228.51
	Dec.	30.08	30.61	26.30	30.08	0	0	-3.78	224.73
1916	Jan.	30.08	30.61	13.50	29.99	0.09	0	-16.58	208.15
	Feb.	28.14	28.63	7.00	26.99	1.15	0	-21.14	187.01
	Mar.	30.08	30.61	4.00	24.87	5.21	0	-26.08	160.93
	Apr.	29.14	29.65	2.90	25.64	3.50	0	-26.24	134.69
	May	30.08	30.61	2.40	23.83	6.25	0	-27.68	107.01
	June	29.14	29.65	5.00	0	29.14	0	-24.14	82.87
	July	30.08	30.61	13.70	0	30.08	0	-16.38	66.49
	Aug.	30.08	30.61	61.00	0	30.08	0	+30.92	97.41
	Sept.	29.14	29.65	165.50	0	29.14	0	+136.36	233.77
TOTALS		355.26	361.50	442.80	210.45	144.81	0	+87.54	-
1916	Oct.	30.08	30.61	126.50	20.81	9.27	0	+96.42	330.19
	Nov.	29.14	29.65	82.70	28.24	0.90	0	+53.56	383.75
	Dec.	30.08	30.61	39.40	30.08	0	0	+9.32	393.07
1917	Jan.	30.08	30.61	20.20	29.99	0.09	0	-9.88	383.19
	Feb.	27.13	27.61	11.00	26.99	0.14	0	-16.13	367.06
	Mar.	30.08	30.61	6.90	24.87	5.21	0	-23.18	343.88
	Apr.	29.14	29.65	5.00	25.64	3.50	0	-24.14	319.74
	May	30.08	30.61	4.00	23.83	6.25	0	-26.08	293.66
	June	29.14	29.65	6.00	0	29.14	0	-23.14	270.52
	July	30.08	30.61	16.70	0	30.08	0	-13.38	257.14
	Aug.	30.08	30.61	67.00	0	30.08	0	+36.92	294.06
	Sept.	29.14	29.65	149.50	0	29.14	0	+120.36	414.42
TOTALS		354.25	360.42	534.90	210.45	143.80	0	+180.65	-

Sept. 1962

TABLE III-2

COMPUTATION OF FINCHAA FARM DELIVERY REQUIREMENT

	Average monthly data (millimeters)								Total
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	
Consumptive use	98.0	96.0	101.0	100.0	92.0	111.0	111.0	114.0	823.0
Util. rain (80%)	32.0	6.4	5.6	4.8	6.4	32.0	29.6	38.4	155.2
Net C.U.	66.0	89.6	95.4	95.2	85.6	79.0	81.4	75.6	667.8
F.I. efficiency	.7	←					→	.7	.7
Water requirement	94.3	128.0	136.3	136.0	122.3	112.8	116.3	108.0	954.0

Elevation 1450 meters

May 8, 1963

4

TABLE III-3

INFLOW DESIGN FLOOD--FINCHAA DAMSITE--BLUE NILE PROJECT

Time hours	Q cu m per sec	Time hours	Q cu m per sec
0	50.0		
6	305.0	126	277.2
12	612.9	132	268.8
18	951.2	138	260.7
24	1,195.0	144	252.9
30	383.8	150	245.4
36	401.4	156	238.2
42	406.0	162	231.2
48	403.7	168	224.5
54	397.3	174	218.0
60	388.3	180	211.8
66	378.0	186	205.8
72	367.4	192	200.0
78	356.6	198	194.4
84	345.9	204	189.1
90	335.0	210	184.0
96	324.4	216	179.0
102	314.2	222	174.2
108	304.4	228	169.6
114	295.0	234	165.2
120	285.9	240	160.9*

*Discharge may be extended by $K_{6hr} = 0.963$

10-day volume = 279.7 million cu m or 226,800 acre-feet

(See Reclamation Instructions IV 6.6 14C) $Q_t = Q_o K^t$

Q_t = discharge t days after Q_o is measured

K = daily depletion factor

TABLE III-4 - FLOOD FREQUENCY AT DAMSITES
FINCHAA AND AMARTI-NESHE PROJECTS

Reservoir	Momentary peak inflow in cu. m./sec. expected to be exceeded once in 5, 10, 25, 50, and 100 years				
	(5)	(10)	(25)	(50)	(100)
Finchaa (Fi-1)	53	53	54	54	54
Amarti (AM-1)	200	230	280	310	340
Neshe (NES-1)	240	290	330	380	410
Amarti-Neshe combined	400	460	530	600	650
Finchaa Diversion					
From frequency curve for record at gage	53	53	54	54	54
Gage to diversion dam = 195 sq. kms.	160	190	220	260	290
Power release	11	11	11	11	11
Total Finchaa Diversion	224	254	285	325	355
Neshe Diversion*	25	32	40	50	55

* Assume Neshe storage dam diverting the Neshe to the Amarti spillway and only the 22.5 square kilometers below it contributing. Add 10 cubic meters per second to each item as power release.

TABLE III-5
RESERVOIR OPERATION STUDY

NESHE AND AMARTI RESERVOIRS--NESHE AND AMARTI RIVERS

RESERVOIR	Min STORAGE (million cu meters)	Max ELEVATION	Max STORAGE (million cu meters)
NESHE	152.9	2,233.98 m	674
AMARTI	12.6	2,233.98	77
Total	165.5 (134,200 ac-ft)		751 (609,000 ac-ft)

FIRM YIELD 310,000,000 cu m per year (251,000 ac-ft) 8,490 hectares served (20,979 acres)

Canal elev. at dam	2,208 m
Canal elev. at tunnel	2,205 m
Jet nozzle elevation	1,625 m
Av. head losses	20 m
Net generator head	560 m
Gen. and turb. eff.	80%

Year	Months	Power generation kw-hr x 10^6	Total inflow to Neshe and Amarti Reservoirs	Total av. surface area m^2 x 10^6	Evaporation and precipitation correction	Power and irrigation release	Spill	Change in storage	End of month reservoir storage	Irrigation demand
		1	2	3	4	5	6	7	8	9
									751	
1911	Oct.	32.9	54	48	0	27	27	0	751	11.44
	Nov.	30.5	8	48	-4	25	0	-21	730	15.52
	Dec.	32.9	0	46	-4	27	0	-31	699	16.53
1912	Jan.	31.7	0	44	-3	26	0	-29	670	16.50
	Feb.	30.5	0	42	-4	25	0	-29	641	14.83
	Mar.	32.9	0	38	-4	27	0	-31	610	13.68
	Apr.	30.5	0	37	-4	25	0	-29	581	14.11
	May	31.7	0	34	-3	26	0	-29	552	13.10
	June	30.5	6	32	+1	25	0	-18	534	0
	July	32.9	20	31	+1	27	0	-6	528	0
	Aug.	31.7	54	32	+1	26	0	+29	557	0
	Sept.	30.5	104	37	0	25	0	+79	636	0
TOTALS		379.2	246		-23	311	27	-115		115.71
1912	Oct.	32.9	42	41	0	27	0	+15	651	11.44
	Nov.	30.5	6	40	-3	25	0	-22	629	15.52
	Dec.		0	38	-3	27	0	-30	599	16.53
1913	Jan.	31.7	0	35	-3	26	0	-29	570	16.50
	Feb.	29.3	0	33	-3	24	0	-27	543	14.83
	Mar.	32.9	0	31	-3	27	0	-30	513	13.68
	Apr.	30.5	0	31	-3	25	0	-28	485	14.11
	May	31.7	0	30	-2	26	0	-28	457	13.10
	June	30.5	4	29	+1	25	0	-20	437	0
	July	32.9	12	29	+1	27	0	-14	423	0
	Aug.	31.7	28	29	+1	26	0	+3	426	0
	Sept.	30.5	54	29	0	25	0	+29	455	0
TOTALS		378.0	146		-17	310	0	181		115.71

Dec. 1962

Year	Months	Power generation kw-hr x 10^6	Total inflow to Neshe and Amarti Reservoirs	Total av. surface area m^2 x 10^6	Evaporation and pre-cipitation correction	Power and irrigation release	Spill	Change in storage	End of month reservoir storage	Irrigation demand
		1	2	3	4	5	6	7	8	9
									455	
1913	Oct.	32.9	22	30	0	27	0	-5	450	11.44
	Nov.	30.5	2	29	-2	25	0	-25	425	15.52
	Dec.	32.9	0	28	-2	27	0	-29	396	16.53
1914	Jan.	31.7	0	28	-2	26	0	-28	368	16.50
	Feb.	29.3	0	27	-2	24	0	-26	342	14.83
	Mar.	32.9	0	26	-3	27	0	-30	312	13.68
	Apr.	30.5	0	25	-2	25	0	-27	285	14.11
	May	31.7	0	23	-2	26	0	-28	257	13.10
	June	30.5	10	22	0	25	0	-15	242	0
	July	32.9	30	22	+1	27	0	+4	246	0
	Aug.	31.7	78	23	+1	26	0	+53	299	0
	Sept.	30.5	152	27	0	25	0	+127	426	0
TOTALS		378.0	294		-13	310		-29		115.71

1914	Oct.	32.9	60	29	0	27	0	+33	459	11.44
	Nov.	30.5	8	30	-3	25	0	-20	439	15.52
	Dec.	32.9	0	29	-2	27	0	-29	410	16.53
1915	Jan.	31.7	0	28	-2	26	0	-28	382	16.50
	Feb.	29.3	0	27	-2	24	0	-26	356	14.83
	Mar.	32.9	0	26	-3	27	0	-30	326	13.68
	Apr.	30.5	0	25	-2	25	0	-27	299	14.11
	May	31.7	0	24	-2	26	0	-28	271	13.10
	June	30.5	6	23	+1	25	0	-18	253	0
	July	32.9	20	22	+1	27	0	-6	247	0
	Aug.	31.7	52	23	+1	26	0	+27	274	0
	Sept.	30.5	100	25	0	25	0	+75	349	0
TOTALS		378.0	246		-13	310		-77		115.71

Dec. 1962

4

Year	Months	Power generation kw-hr x 10^6	Total inflow to Neshe and Amarti Reservoirs	Total av. surface area m^2 x 10^6	Evaporation and pre-cipitation correction	Power and irrigation release	Spill	Change in storage	End of month reservoir storage	Irrigation demand
		1	2	3	4	5	6	7	8	9
									349	
1915	Oct.	32.9	40	27	0	27	0	+13	362	11.44
	Nov.	30.5	6	27	-2	25	0	-21	341	15.52
	Dec.	32.9	0	26	-2	27	0	-29	312	16.53
1916	Jan.	31.7	0	25	-2	26	0	-28	284	16.50
	Feb.	30.5	0	23	-2	25	0	-27	257	14.83
	Mar.	32.9	0	22	-2	27	0	-29	228	13.68
	Apr.	30.5	0	21	-2	25	0	-27	201	14.11
	May	31.7	0	19	-1	26	0	-27	174	13.10
	June	30.5	16	18	0	25	0	-9	165	0
	July	32.9	46	19	+1	27	0	+20	185	0
	Aug.	31.7	118	22	+1	26	0	+93	278	0
	Sept.	30.5	228	27	0	25	0	+203	481	0
TOTALS		379.2	454		-11	311		+132		115.71

1916	Oct.	32.9	92	31	0	27	0	+65	546	11.44
	Nov.	30.5	12	32	-3	25	0	-16	530	15.52
	Dec.	32.9	0	31	-3	27	0	-30	500	16.53
1917	Jan.	31.7	0	30	-2	26	0	-28	472	16.50
	Feb.	29.3	0	30	-3	24	0	-27	445	14.83
	Mar.	32.9	0	29	-3	27	0	-30	415	13.68
	Apr.	30.5	0	28	-3	25	0	-28	387	14.11
	May	31.7	0	27	-2	26	0	-28	359	13.10
	June	30.5	18	27	+1	25	0	-6	353	0
	July	32.9	56	27	+1	27	0	+30	383	0
	Aug.	31.7	144	29	+1	26	00	+119	502	0
	Sept.	30.5	278	0	0	25	4	+249	751	0
TOTALS		378.0	600		-16	310	4	+270		115.71

Dec. 1962

50

TABLE III-6

COMBINED AREA-CAPACITY TABLE AFTER 50 YEARS
NESHE-AMARTI RESERVOIR--BLUE NILE PROJECT

Elevation (M)	Area (million sq m)	Capacity (million cu m)	
2234	46.9	731.4	
29	30.5	535.5	
25	28.1	434.7	
20	24.7	325.0	Note: The Amarti portions of the reservoir area and capacity below elevation 2229 (invert of cross channel) are unusable and remain constant at 3.8 million sq m and 8.1 million cu m, respectively, as the reservoir is drawn down below that elevation.
15	20.7	231.7	
10	16.8	155.6	
5	13.4	98.7	
2200	10.4	57.6	
95	7.8	29.7	
90	5.8	14.5	
85	4.2	8.3	
83.6	3.8	8.1	

Sept. 26, 1963

5

TABLE III-6

50-YR. SEDIMENT DISTRIBUTION--AMARTI RESERVOIR (WITHOUT NESHE)--BLUE NILE PROJECT

Area Increment Method

Elevation (M)	Original area (million sq m)	Original capacity (million cu m)	Ao (million sq m)	Sediment volume (million cu m)	50-year revised	
					Area (million sq m)	Capacity (million cu m)
2234	18.7	77.3	1.2	10.5	17.5	66.8
33	16.5	60.6	1.2	9.3	15.3	51.3
32	13.8	45.0	1.2	8.1	12.6	36.9
31	10.7	29.5	1.2	6.9	9.5	22.6
30	7.6	19.0	1.2	5.7	6.4	13.3
29	5.0	12.6	1.2	4.5	3.8	8.1
28	4.0	7.7	1.2	3.3	2.8	4.4
27	3.0	3.9	1.2	2.1	1.8	1.8
26	2.0	1.1	1.2	0.9	0.8	0.2
25.6	1.2	0.4	1.2	0.4	0	0
25	0	0	0	0	0	0

Sept. 26, 1963

TABLE III-6

50 AND 100-YR. SEDIMENT AT DAM--AMARTI RESERVOIR--BLUE NILE PROJECT

Type III Reservoir

S = 10.5 million cu m (50 yrs.) 21.0 million cu m (100 yrs.)

Assume maximum normal water surface at elevation 2234, then H = 9

Elevation	p	V(pH)	S-V(pH)	HA(pH)	h'p
			50 yrs.		
2225.5	0.056	0.3	10.2	9.0	1.133
2226	0.111	1.1	9.4	18.0	0.522
2227	0.222	3.9	6.6	27.0	0.244
2225.25	0.0278	0.1	10.4	4.5	2.31
			100 yrs.		
2225.5	0.056	0.3	20.7	9.0	2.30
2226	0.111	1.1	19.9	18.0	1.106
2227	0.222	3.9	17.1	27.0	0.633
2227.5	0.278	5.7	15.3	31.5	0.486
2228	0.333	7.7	13.3	36.0	0.370
2229	0.444	12.6	8.4	45.0	0.187

Sept. 26, 1963

5.

TABLE III-6

50-YR. SEDIMENT DISTRIBUTION--NESHE RESERVOIR (WITHOUT AMARTI)--BLUE NILE PROJECT

Area Increment Method

Elevation (M)	Original area (million sq m)	Original capacity (million cu m)	Ao (million sq m)	Sediment volume (million cu m)	50-year revised	
					Area (million sq m)	Capacity (million cu m)
Flood pool				10.5		
2234	29.6	674.8	0.2	10.2	29.4	664.6
29	26.9	536.6	0.2	9.2	26.7	527.4
25	24.5	435.0	0.2	8.4	24.3	426.6
20	21.1	324.3	0.2	7.4	20.9	316.9
15	17.1	230.0	0.2	6.4	16.9	223.6
10	13.2	152.9	0.2	5.4	13.0	147.5
05	9.8	95.0	0.2	4.4	9.6	90.6
2200	6.8	52.9	0.2	3.4	6.6	49.5
95	4.2	24.0	0.2	2.4	4.0	21.6
90	2.2	7.8	0.2	1.4	2.0	6.4
85	0.6	0.6	0.2	0.4	0.4	0.2
83.6	0.2	0.1	0.2	0.1	0	0
83	0	0	0	0	0	0

Sept. 26, 1963

TABLE III-6

50 AND 100 YR. SEDIMENT AT DAM--NESHE RESERVOIR--BLUE NILE PROJECT

Type III Reservoir

S = 10.5 million cu m (50 yrs.) 21.0 million cu m (100 yrs.)

Assume maximum normal water surface at elevation 2234, then H = 51

Elevation	p	V(pH)	S-V(pH)	HA(pH)	h'p
			50 yrs.		
2183.5	0.0098	0.04	10.46	8.16	1.28
2184	0.0196	0.2	10.3	16.3	0.632
2185	0.0392	0.6	9.9	32.6	0.304
2186	0.0588	1.4	9.1	49.0	0.186
			100 yrs.		
2184	0.0196	0.2	20.8	16.3	1.276
2185	0.0392	0.6	20.4	32.6	0.626
2186	0.0588	1.4	19.6	49.0	0.400

September 26, 1963

At 80 percent turbo-generator efficiency, the operation study shows that the plant can operate under a level load curve (i.e., with approximately the same average kilowatts of generation each month) with an annual generation of 378 million kilowatt-hours, while also serving the irrigation project.

Irrigated Area

Estimated farm delivery requirement for the Amarti-Neshe Project area is 0.954 meter (3.13 feet). This estimate is the same as for the Finchaa Project of similar elevation and location, shown in Table III-2. Allowing 10 percent for canal seepage and 20 percent for operational waste, the operation study shows that, if the reservoir is constructed and operated in accordance with the proposal, much more than 8,490 hectares (20,970 acres) could be irrigated with no shortages.

Spillway Design Flood

Table III-7 shows ordinates of the estimated maximum probable reservoir inflow flood from the two drainage basins. Table III-8 shows ordinates of the maximum probable flood that could come down the Neshe and would have to be passed through the cross channel to be spilled at Amarti dam.

Flood Frequency

Table III-4 shows frequency of floods expected to be encountered during construction at each of the damsites.

Outlet Capacity

In order to provide for peak operation of the Neshe plant at twice the average release (during months of low content), the outlet from Neshe reservoir to the power canal will require a capacity of 20 cubic meters per second (706 cubic feet per second) when water surface is at the minimum operating level of 2229 meters.

TABLE III-7

MAXIMUM PROBABLE FLOOD - NESHE-AMARTI (COMBINED)
BLUE NILE PROJECT

$T_p = 0.749$ $\qquad \frac{ad}{q_p} = \frac{554 \times 10^6 \times 0.195}{1,910} \times 0.749 = 42,400$

a = drainage area in sq meters = 554×10^6

d = depth of runoff in meters = 0.195

q_p = flood peak in cu m per sec = 1,910

Basic ratios T/T_p	Basic ratios q/q_p	Time in thousand sec.	Design flood in cu m per sec: Hydrograph	Base flow a/	Total	Subtotal	Million cu m
0	0	0	0	29	29		
0.1	0.015	4	29	29	58		
0.2	0.075	8	143	29	172		
0.3	0.16	13	306	29	335		
0.4	0.28	17	535	29	564		
0.5	0.43	21	821	29	850		
0.6	0.60	25	1,146	29	1,175		
0.7	0.77	30	1,471	29	1,500		
0.8	0.89	34	1,700	29	1,729		
0.9	0.97	38	1,853	29	1,882		
1.0	1.00	42	1,910	29	1,939		
1.1	0.98	47	1,872	29	1,901		
1.2	0.92	51	1,757	29	1,786		
1.3	0.84	55	1,604	29	1,633		
1.4	0.75	59	1,432	29	1,461		
1.5	0.66	64	1,261	29	1,290		
1.6	0.56	68	1,070	29	1,099	18,839	80.07
1.8	0.42	76	802	29	831		
2.0	0.32	85	611	29	640		
2.2	0.24	93	458	29	487		
2.4	0.18	102	344	29	373		
2.6	0.13	110	248	29	277		
2.8	0.098	119	187	29	216		
3.0	0.075	127	143	29	172	3,460	29.15
3.5	0.036	148	69	29	98		
4.0	0.018	170	34	29	63		
4.5	0.009	191	17	29	46		
5.0	0.004	212	8	29	37	311	6.61
Days		2.45					115.83
		say 2-1/2 days					say 116

$\frac{68}{16} = 4.25$ $\qquad 18,275 \qquad \left(\frac{29+1,099}{2} + 18,275\right)$

$\frac{59}{7} = 8.428$ $\qquad 2,824 \qquad \left(\frac{1,099+172+2,824}{2}\right)$

$\frac{85}{4} = 21.25$ $\qquad 207 \qquad \left(\frac{172+37+207}{2}\right)$

(i.e., 18,839 x 4,250)

a/August (1932) av. = 78 million cu m $\qquad$ 2,673,400 = 29 cu m per sec

Sept. 1963

TABLE III-8

MAXIMUM PROBABLE FLOOD - NESHE (WITHOUT AMARTI)
BLUE NILE PROJECT

$T_p = 0.749$ $\qquad \frac{ad}{q_p} = 0.749 \frac{309 \times 10^6 \times 0.207}{1,240} = 38,650$

a = drainage area in sq meters = 309×10^6

d = depth of runoff in meters = 0.207

q_p = flood peak in cu m per sec = 1,240

Basic ratios		Time in thousand sec.	Design flood in cu m per sec		
T/T_p	q/q_p		Hydro-graph	Base flow a/	Total
0	0	0	0	15	15
0.1	0.015	4	19	15	34
0.2	0.075	8	93	15	108
0.3	0.16	12	198	15	213
0.4	0.28	15	347	15	362
0.5	0.43	19	533	15	548
0.6	0.60	23	744	15	759
0.7	0.77	27	955	15	970
0.8	0.89	31	1,104	15	1,119
0.9	0.97	35	1,203	15	1,218
1.0	1.00	39	1,240	15	1,255
1.1	0.98	42	1,215	15	1,230
1.2	0.92	46	1,141	15	1,156
1.3	0.84	50	1,042	15	1,057
1.4	0.75	54	930	15	945
1.5	0.66	58	818	15	833
1.6	0.56	62	694	15	709
1.8	0.42	70	521	15	536
2.0	0.32	77	397	15	412
2.2	0.24	85	298	15	313
2.4	0.18	93	223	15	238
2.6	0.13	101	161	15	176
2.8	0.098	108	122	15	137
3.0	0.075	116	93	15	108
3.5	0.036	135	45	15	60
4.0	0.018	155	22	15	37
4.5	0.009	174	11	15	26
5.0	0.004	193	5	15	20

a/ August (1932) av. = 39 million cu m $\quad$ 2,678,400 = 15 cu m per sec.

Sept. 1963

58

SECTION IV - GEOLOGY

General Geology of the Area

The headwaters of the Finchaa drainage system originate from high volcanic mountains, composed mostly of basalt, which have been eroded into sharp, steep ridges and valleys. Volcanic plugs, ranging from dark colored basalt to light colored rhyolite, are common physiographic features in this mountainous area.

Northward, at lower elevations the volcanic material feathers out on the wide, flat rolling plateau. In this northward or downstream direction, due to erosion and probably to the thinning of the volcanic lava flows, the streams have cut through the volcanic materials into flat-lying, massive beds of adigrat sandstone, which constitute the principal rocks forming the lower part of the plateau.

In the vicinity of the outlet of the swamp, the ridges are composed of sandstone, but in the valley or canyon the Finchaa River is flowing on an intervalley flow of basalt which was deposited within an older, previously eroded valley. It is believed that the intervalley filling of lava is younger than the "plateau" volcanics and probably originated in the vicinity of the volcanic plugs and cones upstream within the swamp area. It is this intervalley filling of volcanic rock, which is harder than the sandstone, which is responsible for the vertical waterfalls. It has also retarded erosion and entrenchment of the streams in the swamp, resulting in the large, flat, poorly drained, land area on the high plateau. It is on the intervalley volcanic rock in the canyon below the outlet of the swamp that dams and other engineering structures will be constructed to develop the project.

The intervalley volcanic rock is hard and jointed, but it is not extremely porous like most other younger volcanic rock in the Blue Nile River Basin. Apparently it was deposited as a thick, massive flow, whereas most other younger volcanics were deposited in intermittent, thin flows that became scoriaceous and badly broken.

Geologic Reconnaissance

Drawing No. 5.2-Fi-2, Finchaa and Amarti-Neshe areas, covers the general geology in the project areas and at the structure sites. The map was constructed by tracing aerial photographs, after making field inspections on the ground and from helicopter flights. Auger holes were drilled to obtain samples of construction materials and they were analyzed by the Imperial Ethiopian Highway Authority Laboratory.

Seismology

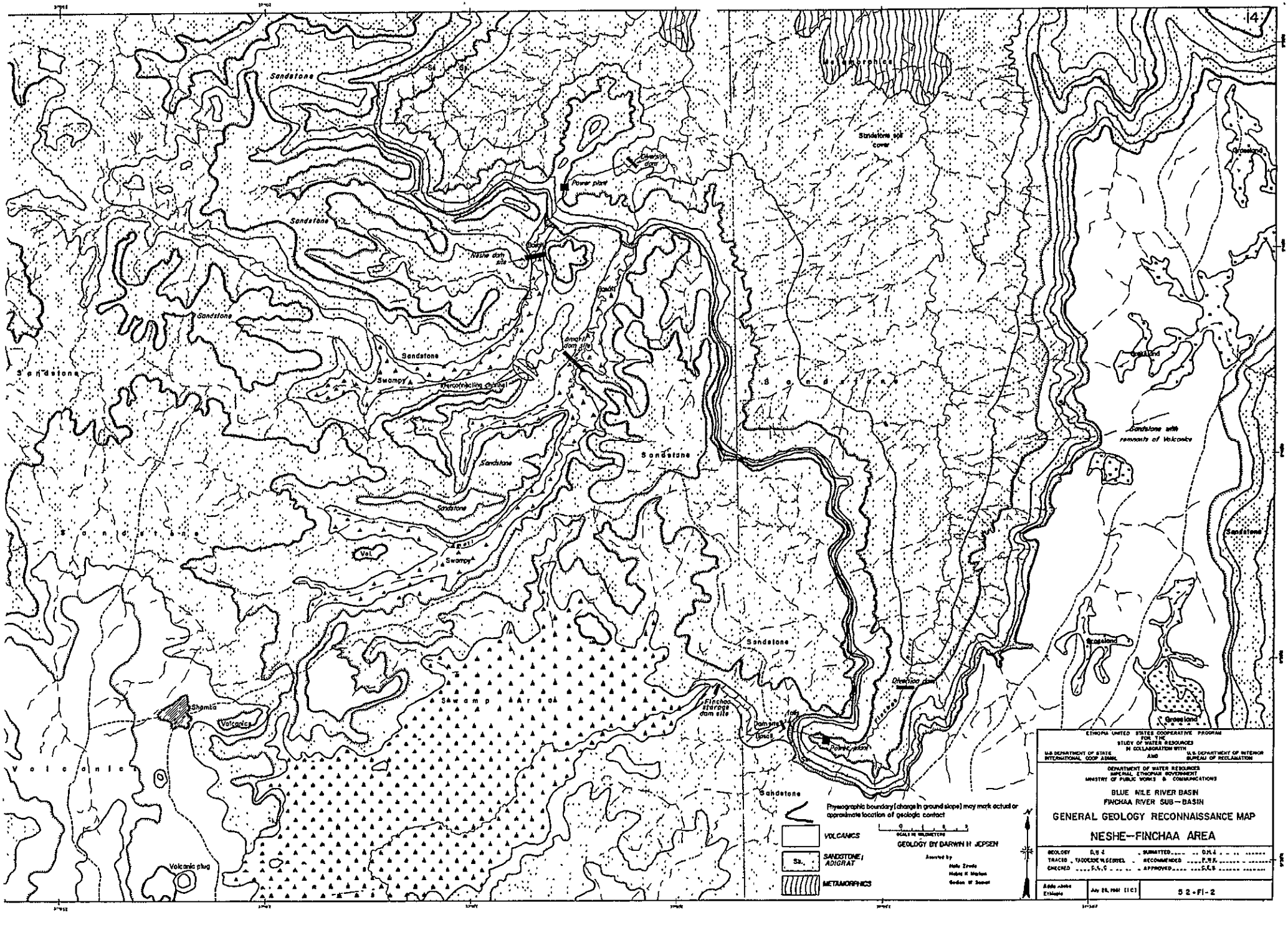
The country of Ethiopia is considered to be in an active seismic area due to the close association with the great rift system passing through Ethiopia. The Ethiopian plateau, of which the Blue Nile River Basin is a part, has been vertically uplifted many hundreds of meters, but it is remarkable that little disturbance or tectonic movements have occurred within the plateau area.

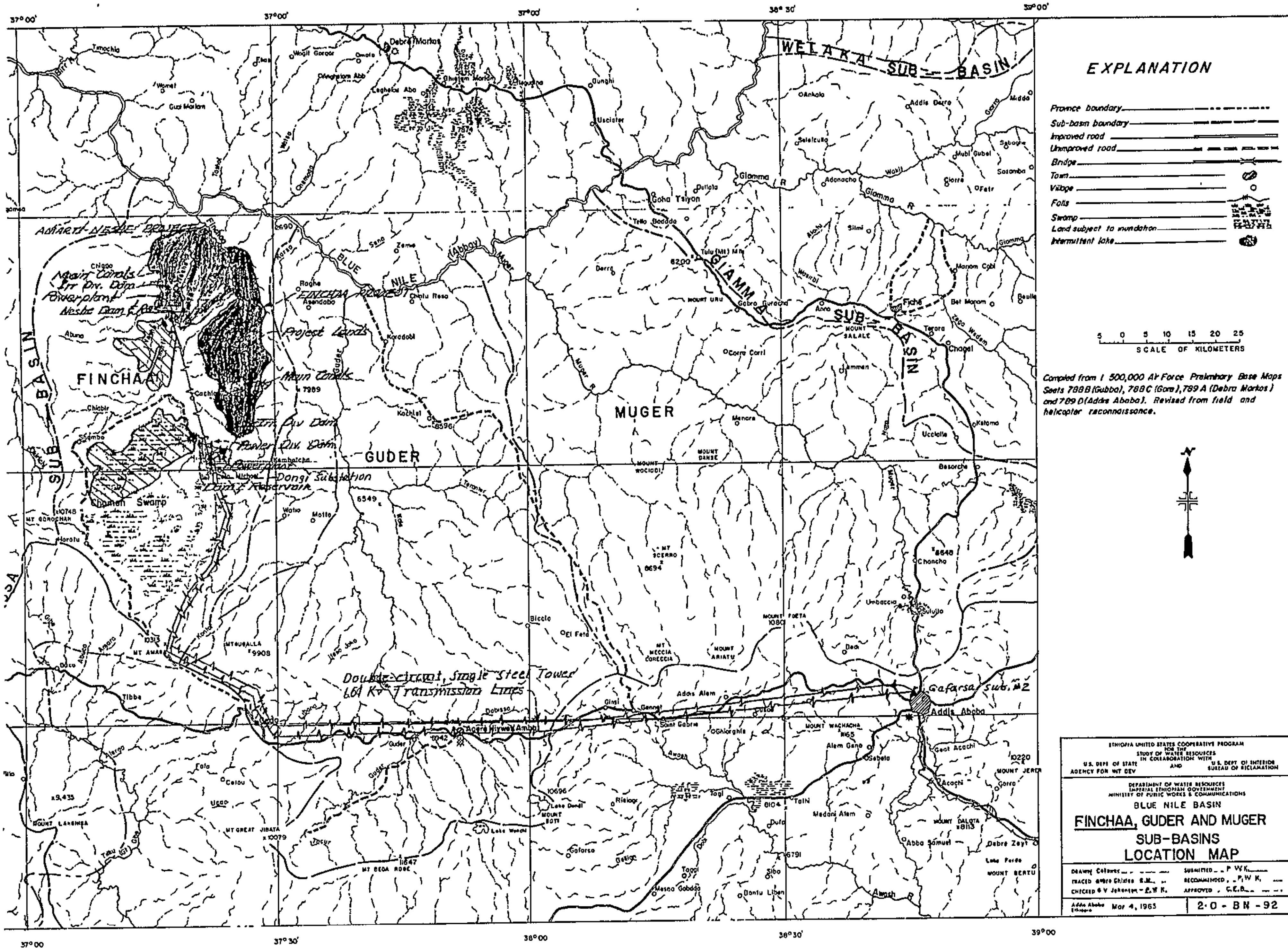
No active faults are known to exist within close proximity to the Finchaa and Amarti-Neshe project area, and certainly not within the structure locations. While structures should be designed with margins of safety to withstand intensive earthquake shocks, no serious problems of a seismic nature are anticipated.

Ground Water

The Finchaa and Amarti-Neshe project areas are on well drained slopes underlain by sandstone. Sources of groundwater supplies for irrigation are not available. The relief and good drainage slopes do not suggest that salt accumulations and water-logging of lands will readily develop in the project areas if irrigation water is properly applied.

AMARTI-NESHE PROJECT (View Upstream)


Sandstone
Metamorphics
Sandstone soil cover
Grassland
Power plant
Diversion dam
Neshe dam site
Finchaa dam site
Finchaa storage dam site
Diversion dam
Power plant
Swampy
Intercontracting channel
Sandstone with remnants of Volcanics
Vol
Swamp area
Shamita
Volcanics
Volcanic plug
Volcanics
Sandstone
Physiographic boundary (change in ground slope) may mark actual or approximate location of geologic contact
VOLCANICS
SANDSTONE; ADIGRAT
METAMORPHICS
SCALE IN KILOMETERS
GEOLOGY BY DARWIN H JEPSEN
Assisted by
Hailu Zewde
Habtu K Mariam
Gordon W Sumner
ETHIOPIA UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH
U.S. DEPARTMENT OF STATE INTERNATIONAL COOP ADMIN.
AND
U.S. DEPARTMENT OF INTERIOR BUREAU OF RECLAMATION
DEPARTMENT OF WATER RESOURCES IMPERIAL ETHIOPIAN GOVERNMENT MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN
FINCHAA RIVER SUB—BASIN
GENERAL GEOLOGY RECONNAISSANCE MAP
NESHE—FINCHAA AREA
GEOLOGY D.H.J. SUBMITTED D.H.J.
TRACED TADDESSE WEGEBSEL RECOMMENDED P.W.K.
CHECKED P.K.C. APPROVED C.C.B.
Addis Ababa Ethiopia
July 28, 1961 (1:C)
52-FI-2


EXPLANATION
Province boundary
Sub-basin boundary
Improved road
Unimproved road
Bridge
Town
Village
Falls
Swamp
Land subject to inundation
Intermittent lake
SCALE OF KILOMETERS
5 0 5 10 15 20 25
Compiled from 1:500,000 Air Force Preliminary Base Maps Sheets 788B (Gubba), 788C (Gore), 789A (Debra Markos) and 789D (Addis Ababa). Revised from field and helicopter reconnaissance.
WELAKA SUB-BASIN
GIAMMA SUB-BASIN
FINCHAA SUB-BASIN
FINCHAA
GUDER
MUGER
BLUE NILE (Abbay)
Glomma R
Awash R
Debra Markos
Fiche
Addis Ababa
Gafarsa Sub. #2
Chomen Swamp
Amarti-Neshe Project
Main Canals
Irr. Div. Dam
Powerplant
Neshe Dam & Res.
Finchaa Project
Project Lands
Main Canals
Irr Div Dam
Power Div. Dam
Powerplant
Dongi Substation
Dam & Reservoir
Double-circuit, Single Steel Tower
164 Kv Transmission Lines
ETHIOPIA UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH
U.S. DEPT OF STATE AGENCY FOR INT DEV AND U.S. DEPT OF INTERIOR BUREAU OF RECLAMATION
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE BASIN
FINCHAA, GUDER AND MUGER
SUB-BASINS
LOCATION MAP
Addis Ababa Ethiopia
Mar 4, 1963
2-0-BN-92

SECTION V - PLANS AND ESTIMATES

Comprehensive Plan of Development

The comprehensive development of the Finchaa Sub-Basin (Dwg. No. 2.0-BN-92) would extend over a long period of years and includes the construction of three storage dams, two irrigation diversion dams, one power diversion dam, one power canal, two pressure tunnels, penstocks, two hydroelectric powerplants, main canals, distribution systems, and drainage canals. The plan envisions the development of approximately 23,500 hectares of land for irrigation and generation of 160,000 kilowatts of hydroelectric power.

The development plan for the Finchaa Sub-Basin is divided into two broad plans--the Finchaa Project and the Amarti-Neshe Project. Both projects would be essentially similar in scope and purpose--the development of the land and water resources for irrigation and hydroelectric power production. The Finchaa Project appears to be the more economically attractive of the two because of its initial low investment, primarily due to the low cost in utilizing Chomen Swamp for storage.

FINCHAA PROJECT

Plan of Development

The multipurpose development plan includes a storage dam, a power diversion dam, a power tunnel and penstocks, a powerplant, transmission facilities, an irrigation diversion dam, two main canals (one on each side of the river), and a distribution system and surface drains to provide irrigation for 15,000 hectares of land and 80,000 kilowatts of power installation.

Storage would be provided by the potential Finchaa Reservoir, made possible by constructing a low dam at the outlet of Chomen Swamp. From this storage, a continuous discharge would be made into the Finchaa River channel whence the flow would be diverted about five kilometers downstream by means of a diversion dam through a tunnel and penstocks for production of hydroelectric power. The

discharge from the powerplant would be made into the river channel below the escarpment and again diverted by another diversion dam into the two main canals to convey the water for irrigation purposes. These canals would roughly parallel the river, the canal on the east side being 56.7 kilometers in length and the one on the west side being 43.1 kilometers in length.

Project Features

The features of the multipurpose project plan are shown in general on Drawing No. 2.0-Fi-2 and are described in reconnaissance detail in the following paragraphs. Topography of the project area (Dwg. No. 2.0-Fi-9) was compiled from stereoscopic projection (multiplex) to a scale of 1:20,000 with 20-meter contour intervals. Controls for the multiplex compilation consisted of (1) horizontal distances measured with tellurometer, third order, and (2) vertical control by trigonometric leveling, using in both cases first order triangulation stations established by the U. S. Coast and Geodetic Survey. Profile of the river is shown in Drawing No. 4.0-BN-74.

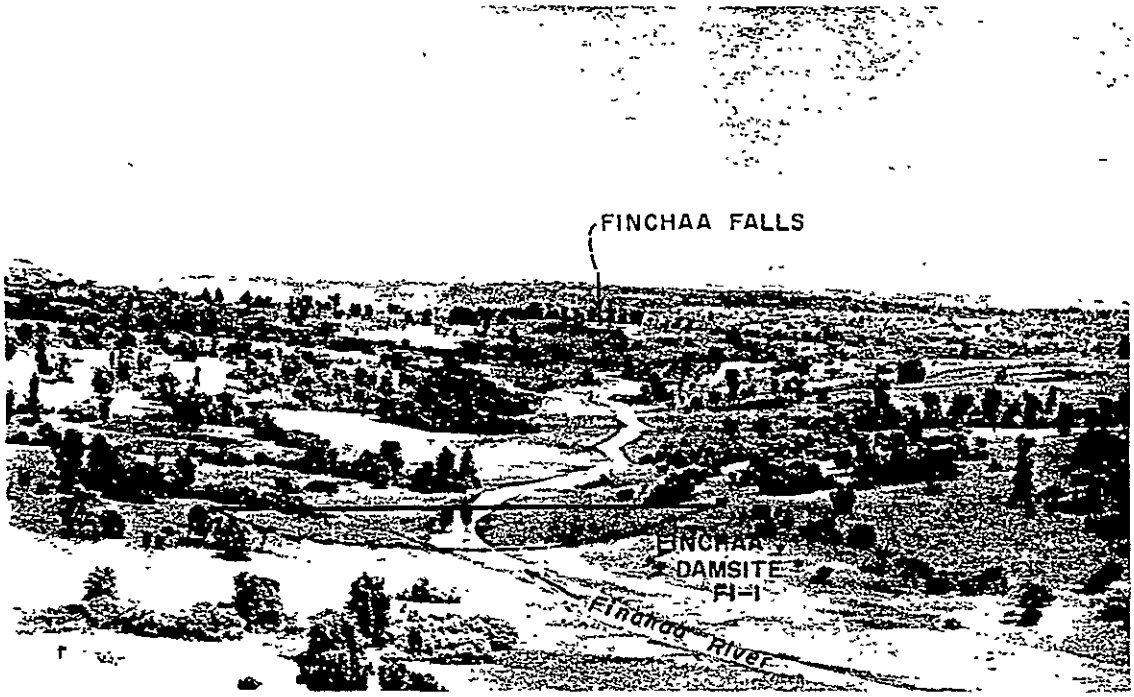
Finchaa Dam and Reservoir

Finchaa Dam. The proposed damsite would be near the outlet of the Chomen Swamp about five kilometers upstream from the Finchaa Falls. It would be a concrete-masonry dam with an ogee-type spillway at the center section. Diversion during construction would be accomplished by gap in the dam, the gap to be closed during the dry season and the floods routed through the completed outlet and spillway section. See Drawing No. OA-23-101 for plan, profile, and section of dam.

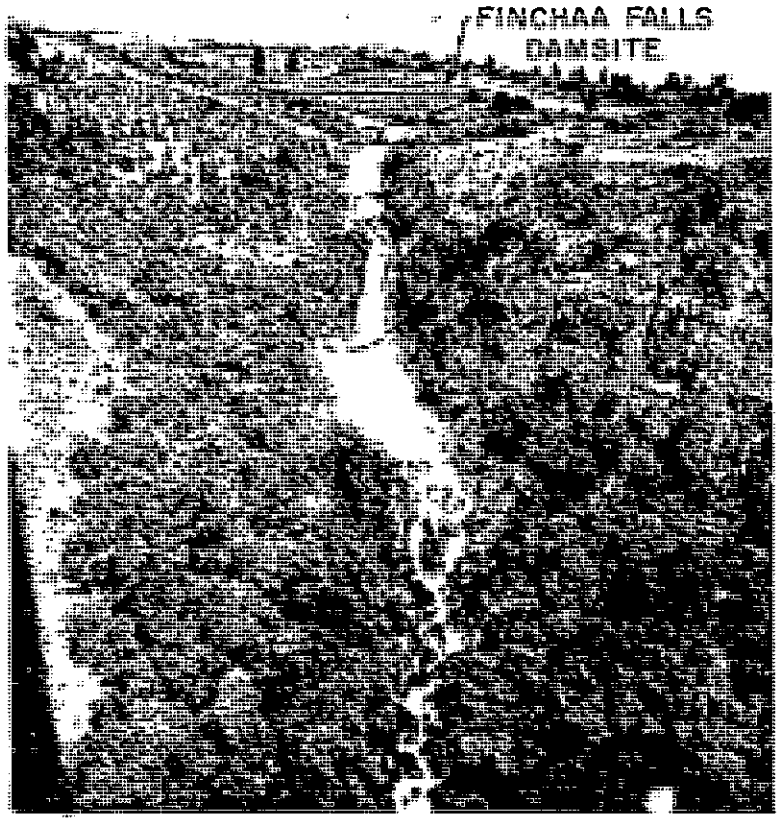
Finchaa Dam Data

Type	masonry-ogee
Volume of concrete and masonry in dam	3,800 cu.m.
Elevation of spillway crest	2213.40 m.
Structural height	8.00 m.
Hydraulic height	7.23 m.
Length of crest	210 m.

Spillway. The design of the spillway was based on an inflow design flood showing a peak inflow of 1,195 cubic meters per second and a 10-day volume of 280 million cubic meters. In routing the flood it was assumed that the reservoir would be at normal water surface elevation 2213.40 meters at the beginning of the flood. The spillway would discharge 70 cubic meters per second at maximum water surface elevation 2214.23 meters.

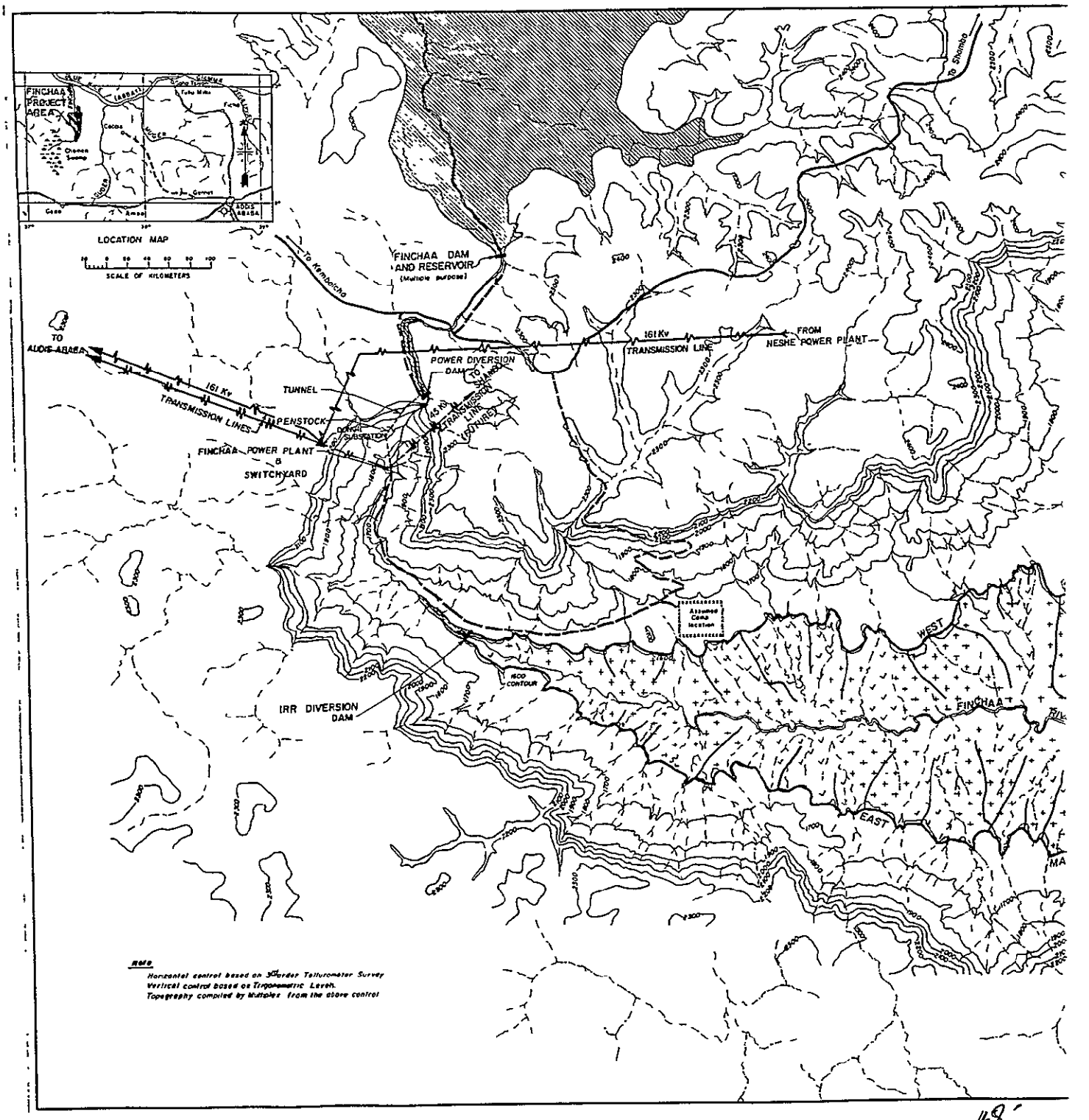


FINCHAA DAMSITE FI-I — LOOKING DOWNSTREAM

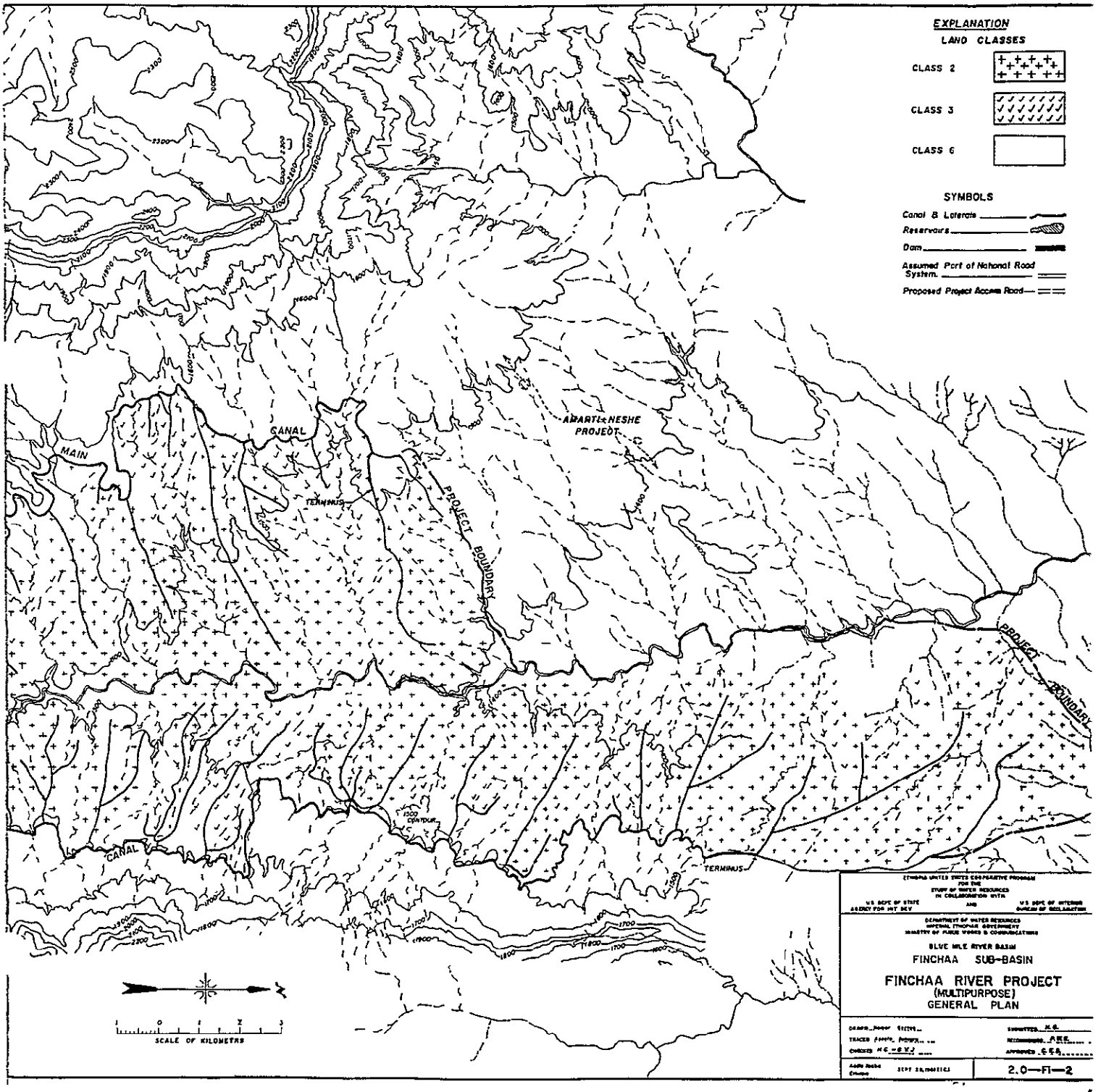


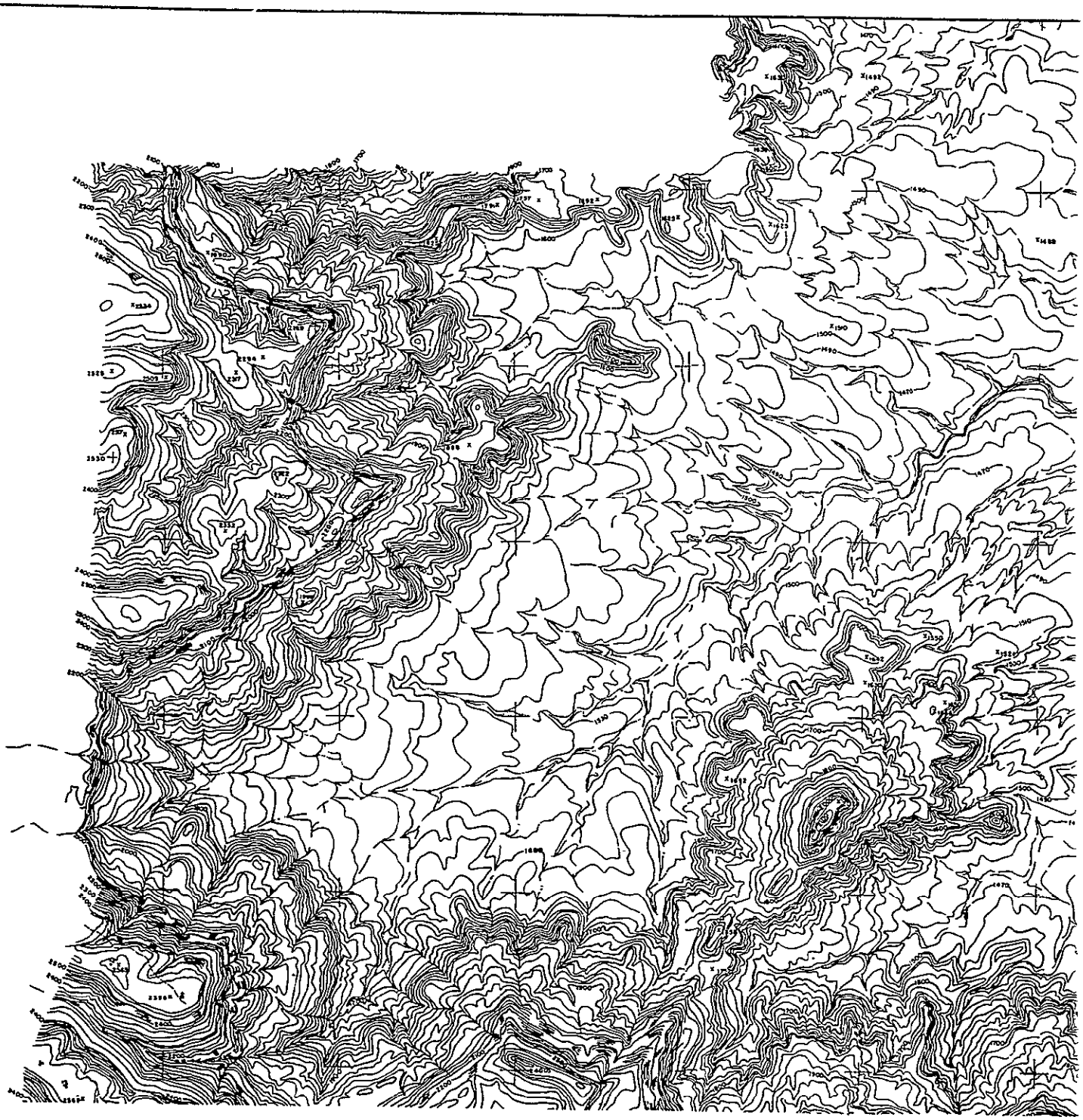
FINCHAA FALLS FI-2 FOREBAY DAMSITE

BEST AVAILABLE COPY

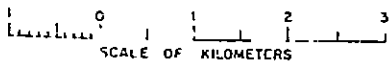


BEST AVAILABLE COPY



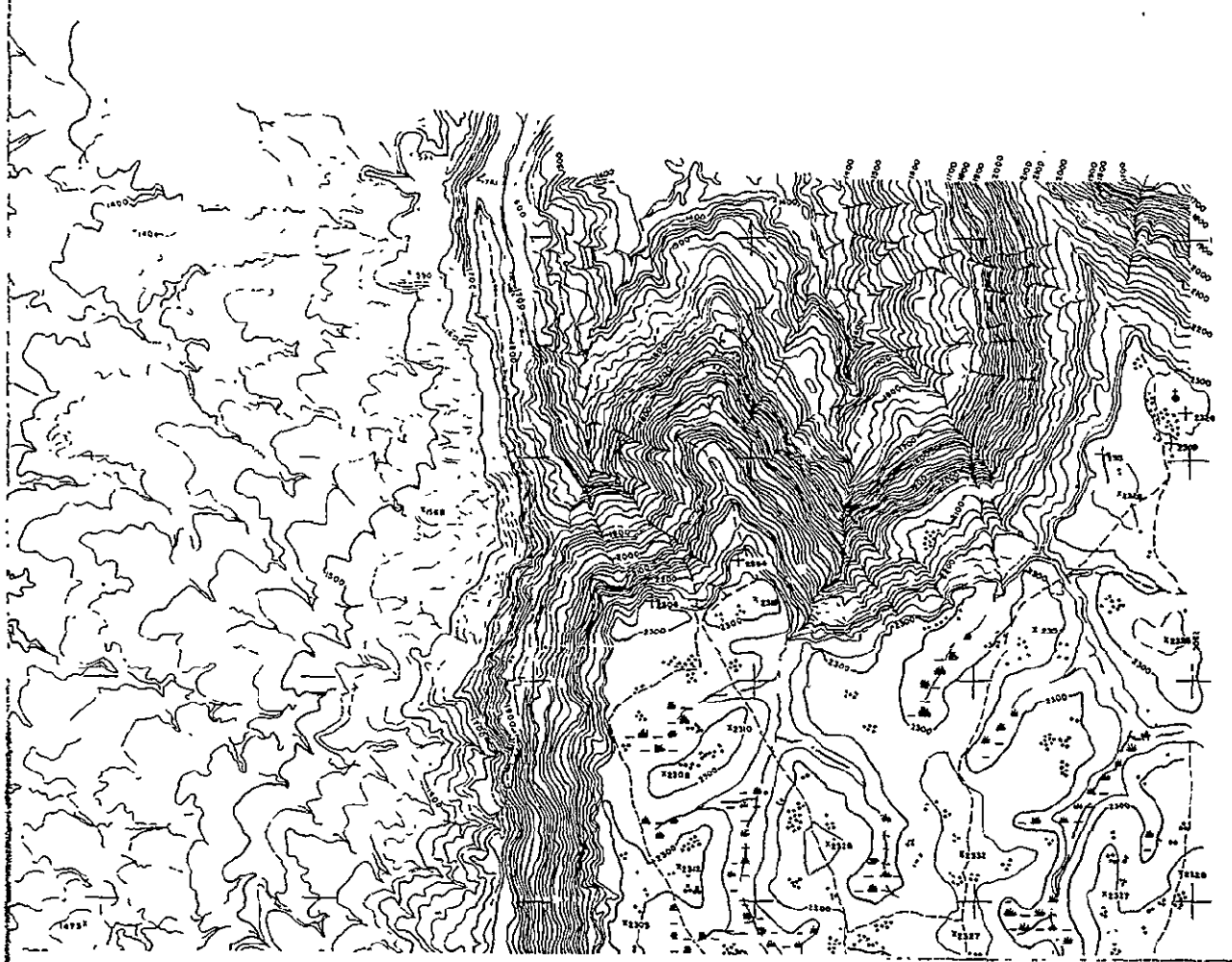


MATCH TO, SHEET 2



NOTES:

1. Horizontal control based on
   Tellurometer survey Vertic
   based on trigonometric le
   Topography compiled by M
   from the above control
2. Contour interval 20 meters.



OTES:

ontal control based on 3rd order
llurometer survey Vertical control
sed on trigonometric levels
pography compiled by Multiplex
om the above control

our interval 20 meters.

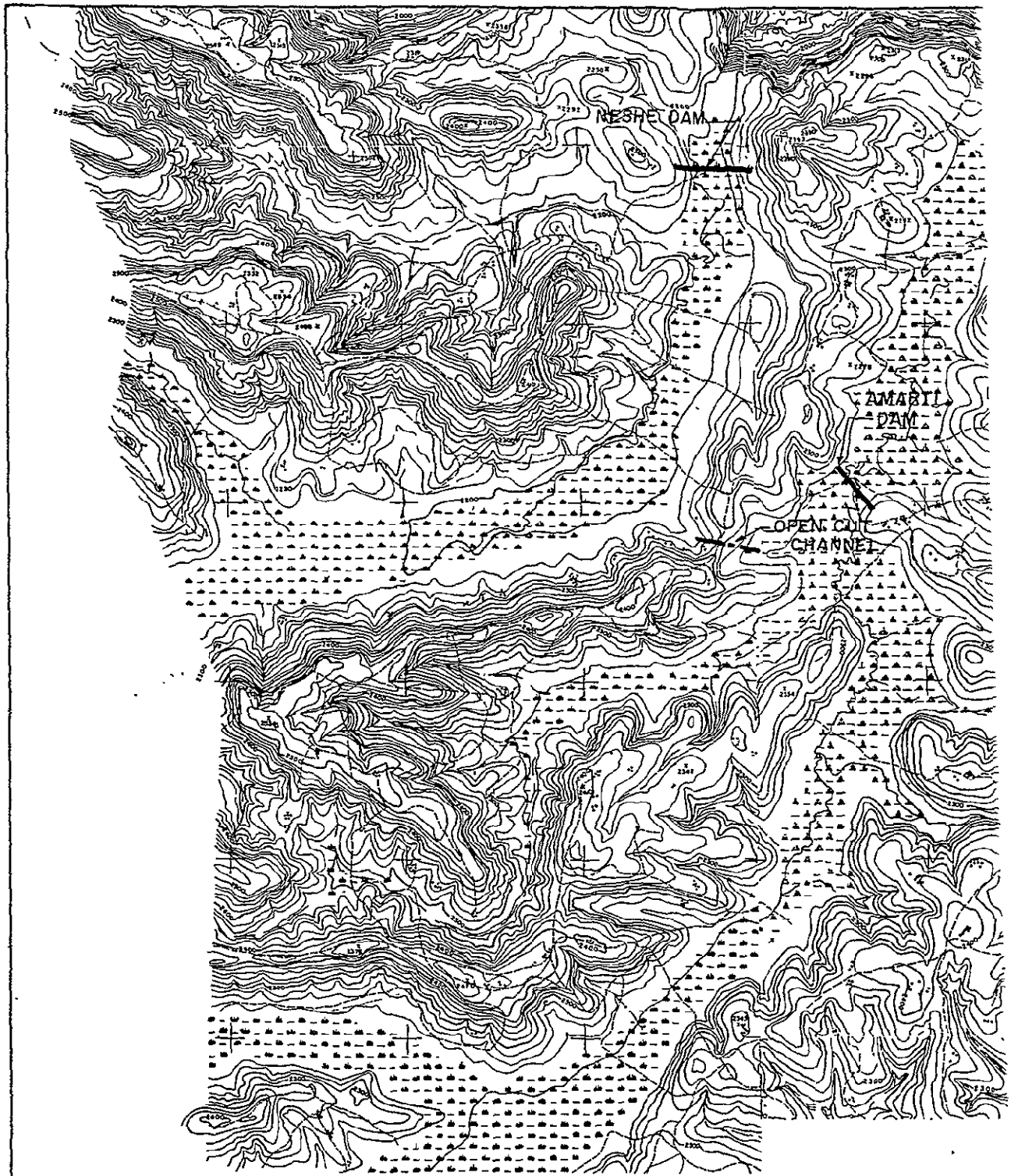
BLUE NILE RIVER BASIN

FINCHAA RIVER AREA TOPOGRAPHY

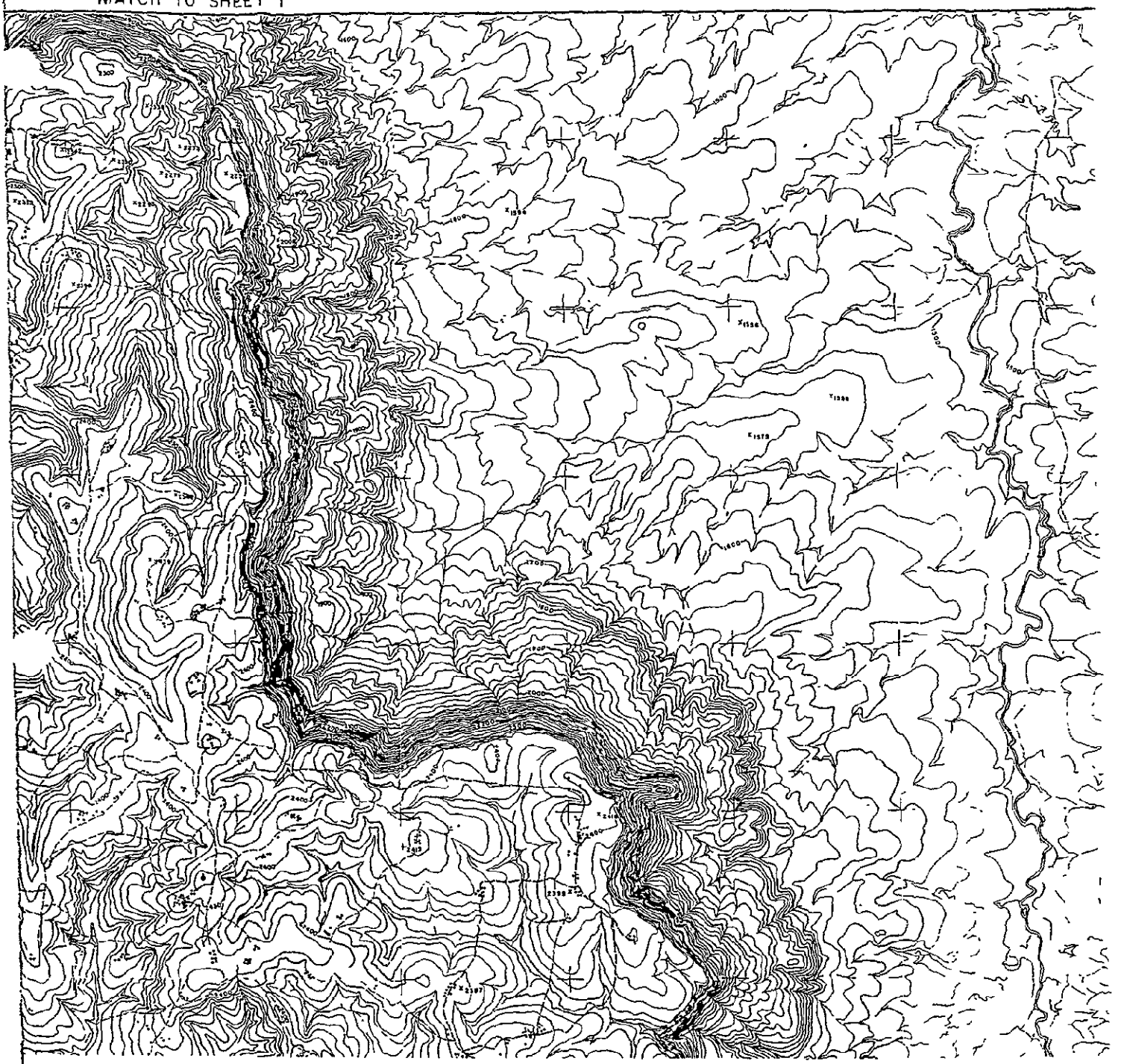
G.V.J.	A.P.B.
N.M.	P.W.K
G.V.J.	C.E.B.

APRIL 4, 1963 (10) 2.0—F1—9

SHEET 1 OF 3


NESHE DAM
AMABTI DAM
OPEN CUT CHANNEL

MATCH TO SHEET 1



MATCH TO SHEET 3

0 1 2 3

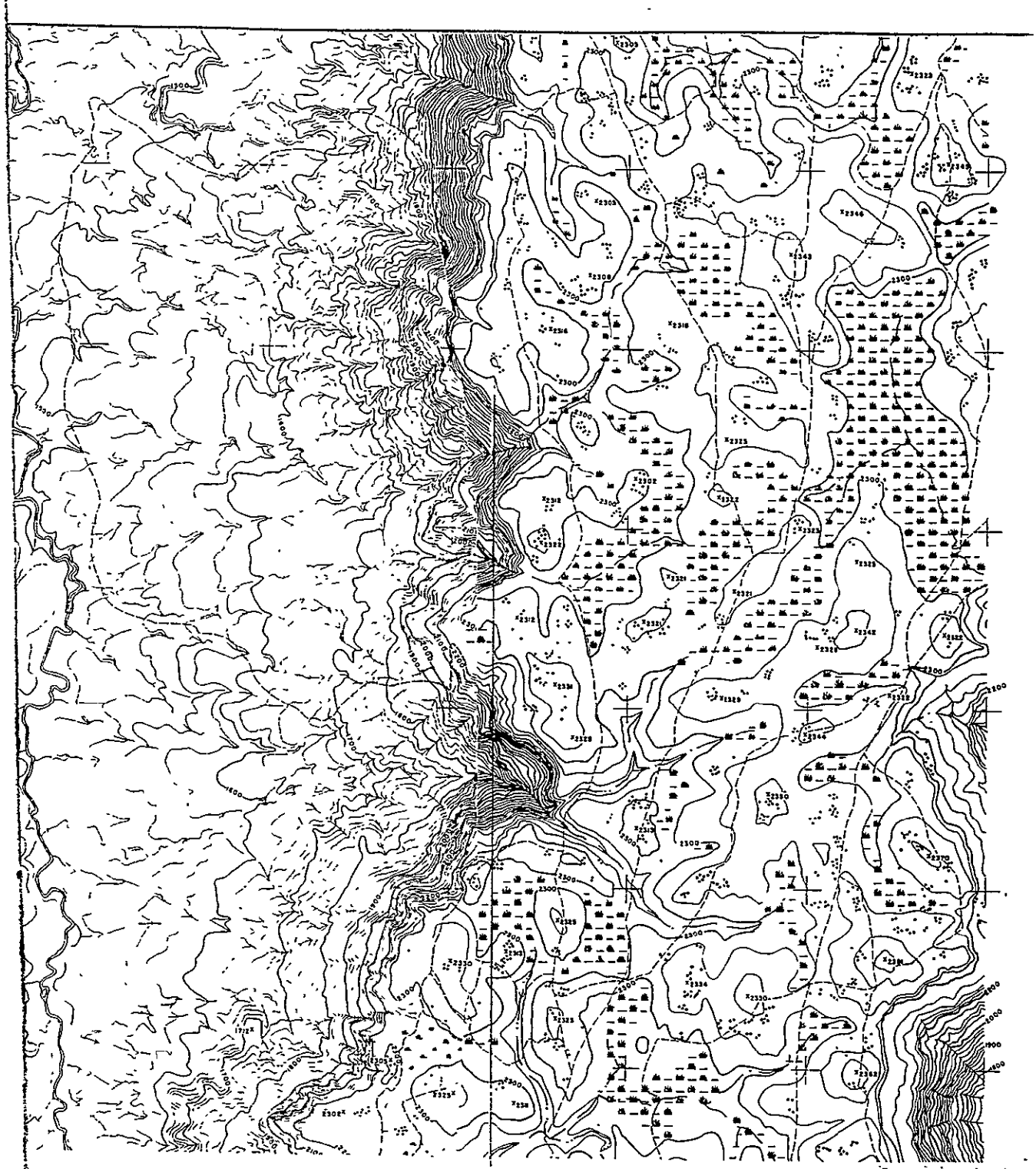
SCALE OF KILOMETERS

NOTES:

1 Horizontal control based Tellurometer survey Ve based on trigonometric Topography compiled b from the above contr

2 Contour interval 20 meter

BEST AVAILABLE COPY



ontrol base on 3rd order
r survey Vertical control
trigonometric levels
compiled by Multiplex
above control

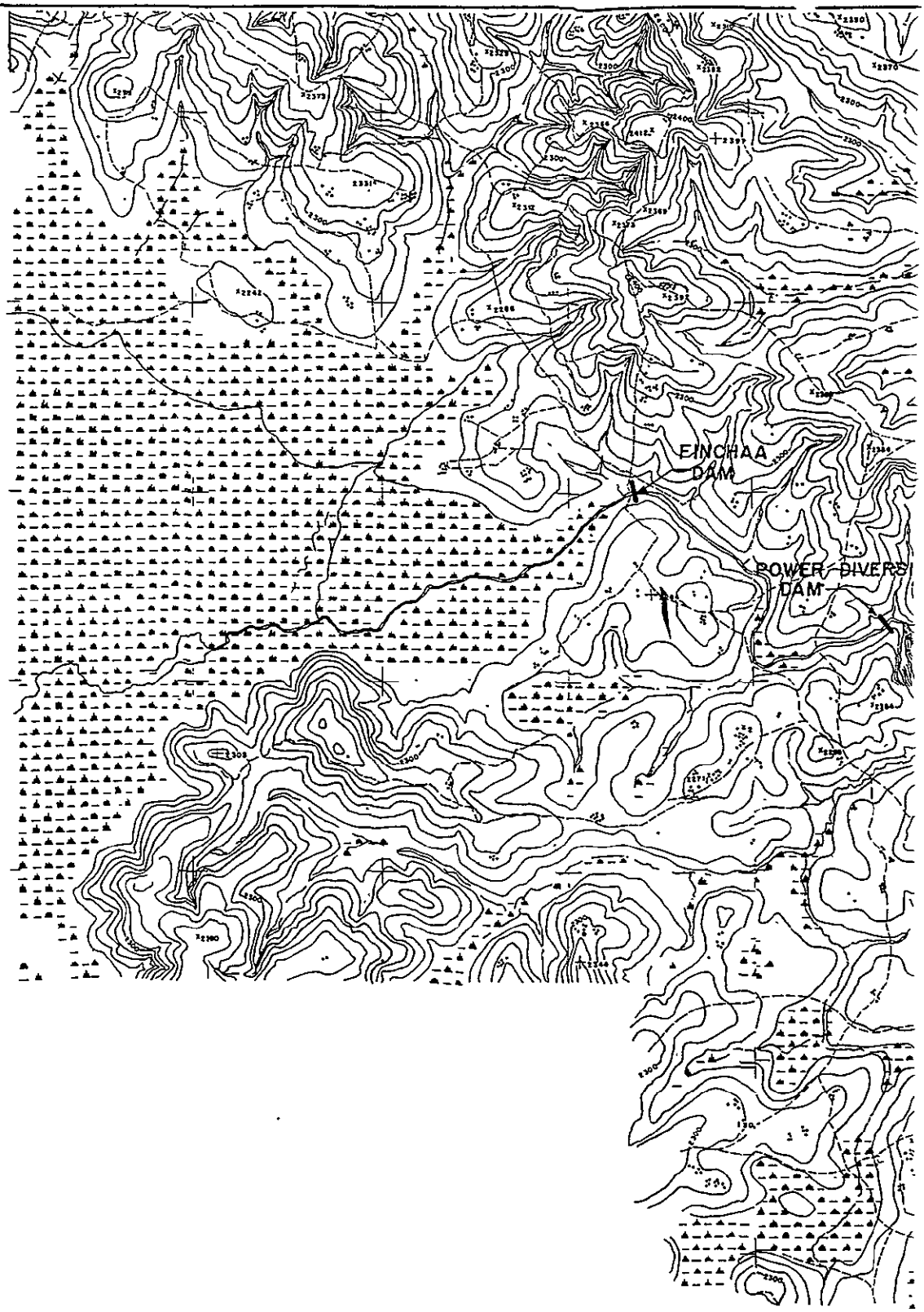
val 20 meters

FINCHAA RIVER AREA
TOPOGRAPHY

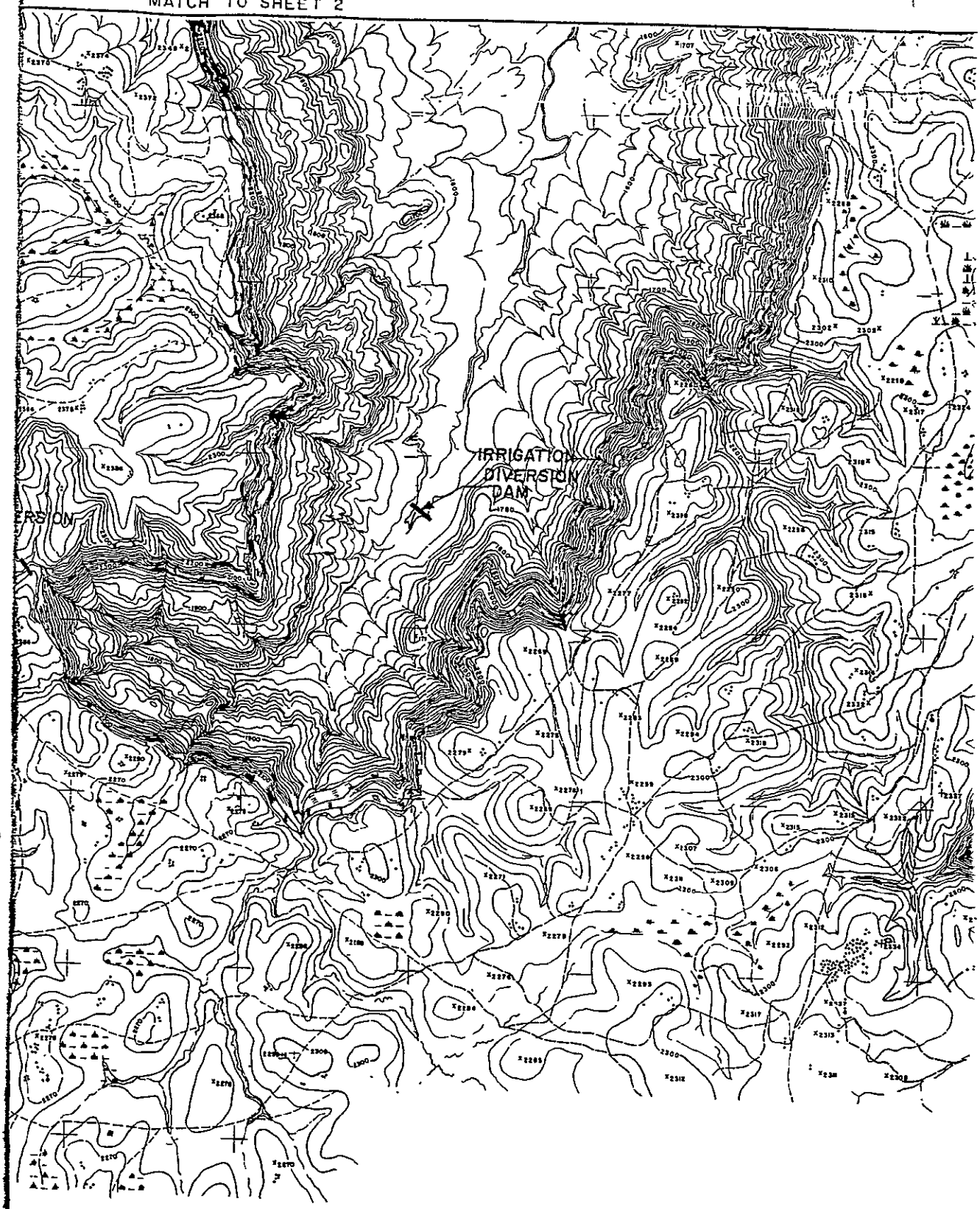
G.V.J
N.M
G.V.J.
A.P.B
P.W.K.
C.E.B.

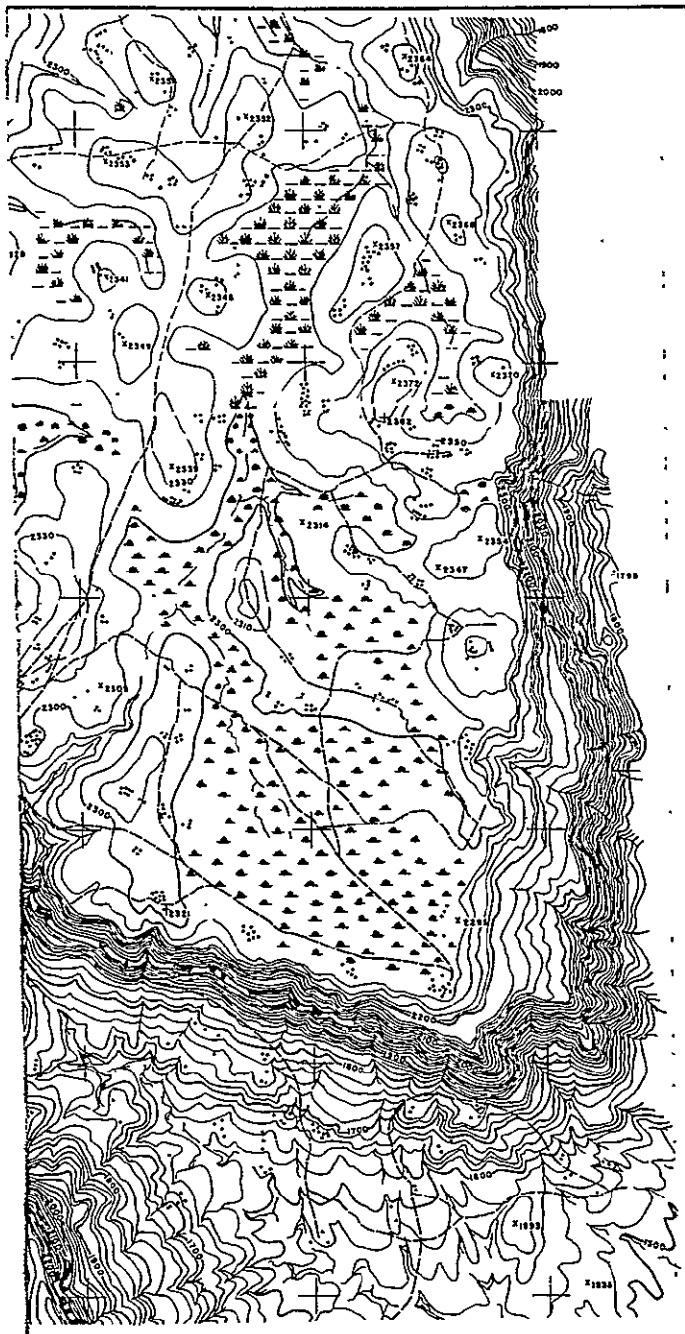
2.0—F1—

SHEET 2 OF 3.


FINCHAA
DAM
POWER DIVERS
DAM

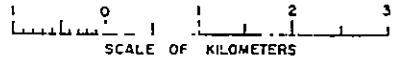
MATCH TO SHEET 2





NOTES:

1. Horizontal control based on 3rd order Tellurometer survey. Vertical control based on trigonometric levels. Topography compiled by Multiplex from the above control.
2. Contour interval 20 meters



ETHIOPIAN UNITED STATES COOPERATIVE PROGRAM
FOR THE
STUDY OF WATER RESOURCES
IN COLLABORATION WITH
U.S. DEPT. OF STATE — INTERNATIONAL COOP. ADMIN. AND U.S. DEPT. OF INTERIOR — BUREAU OF RECLAMATION

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

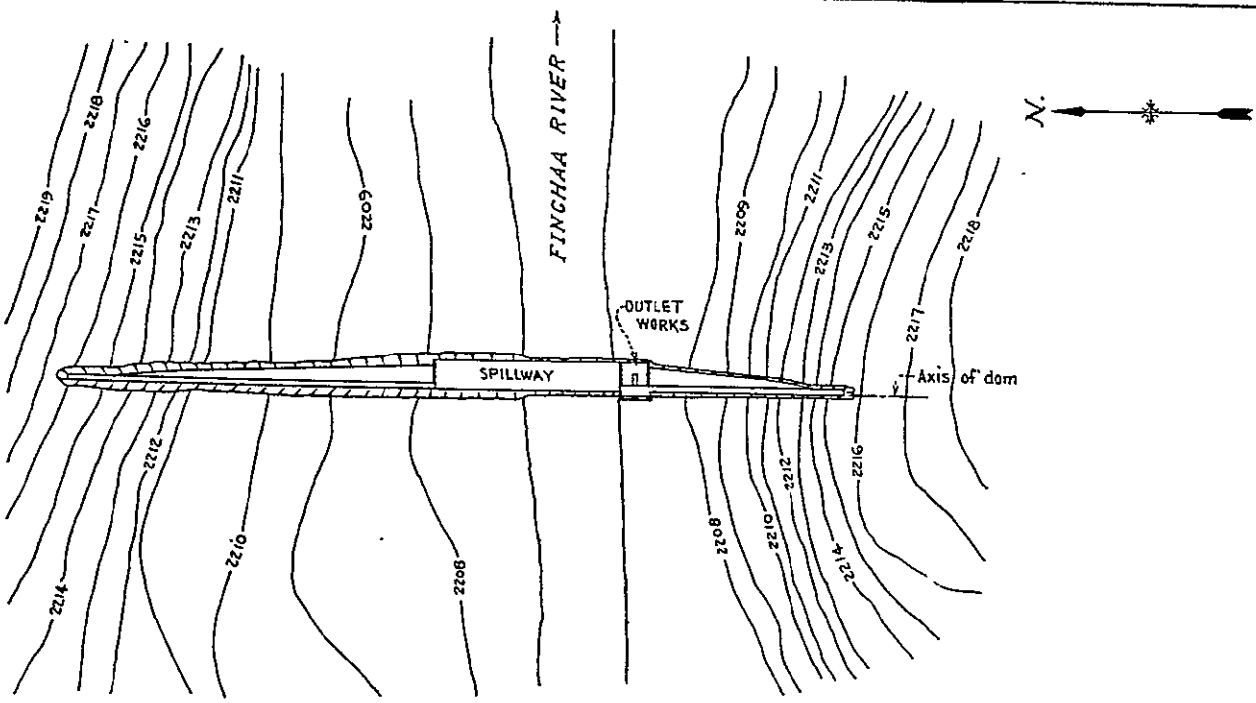
FINCHAA RIVER AREA
TOPOGRAPHY

DRAWN	G. V. J.	SUBMITTED	A. P. B.
TRACED	N. M.	RECOMMENDED	P. W. K.
CHECKED	G. V. J.	APPROVED	C. E. B.

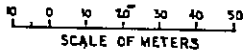
Addis Ababa, Ethiopia APRIL 4, 1963 (LC) 2.0—Fi—9

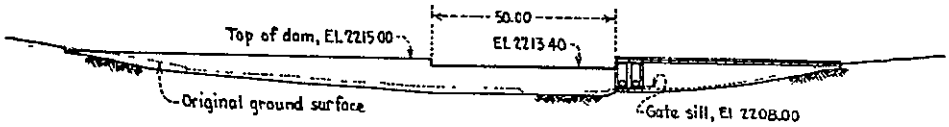
SHEET 3 OF 3.

BEST AVAILABLE COPY

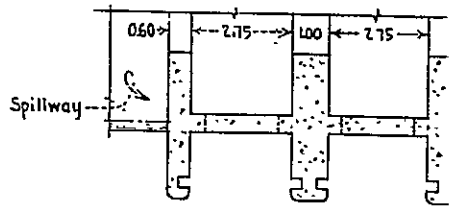


PLAN - FINCHAA STORAGE DAM

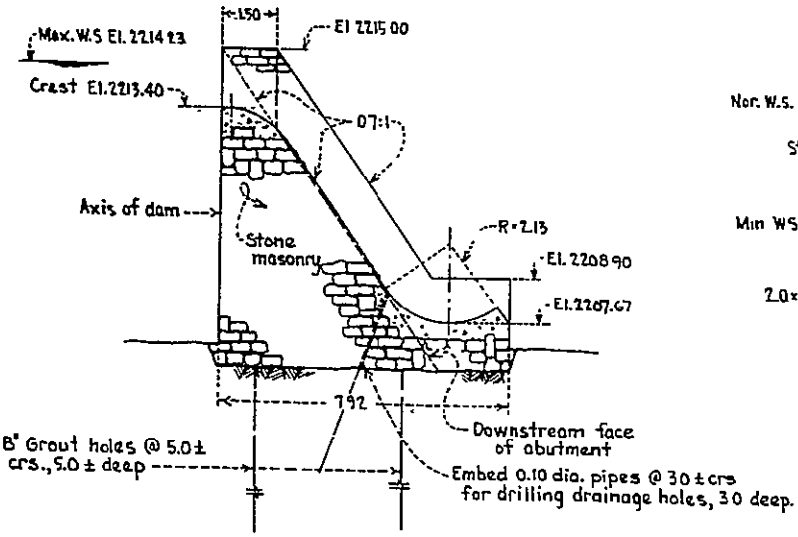




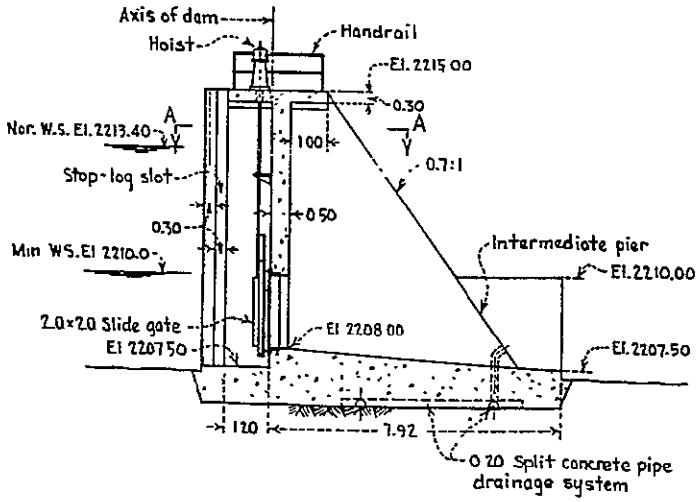
UPSTREAM ELEVATION



SECTION A-A

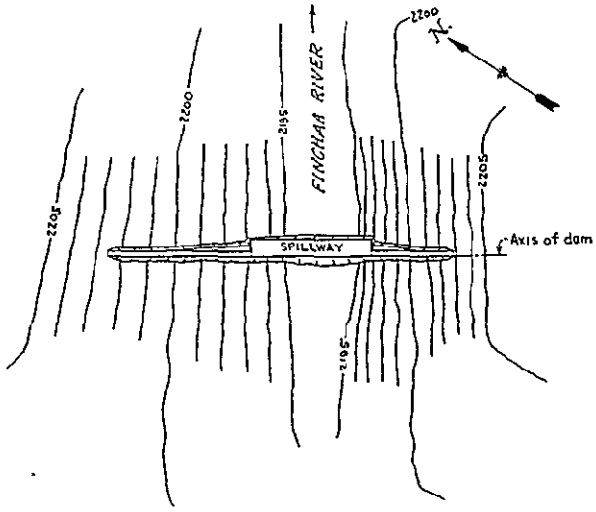


TYPICAL SPILLWAY SECTION



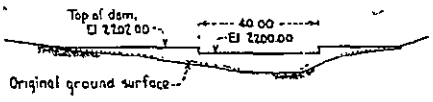
SECTION THRU OUTLET WORKS

BEST AVAILABLE COPY

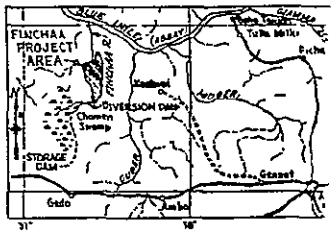


PLAN - FINCHAA POWER DIVERSION DAM

SCALE OF METERS

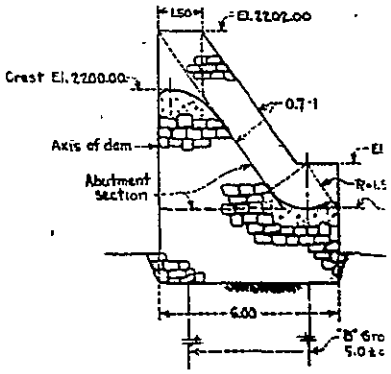


UPSTREAM ELEVATION



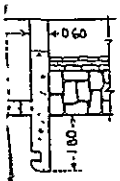
LOCATION MAP

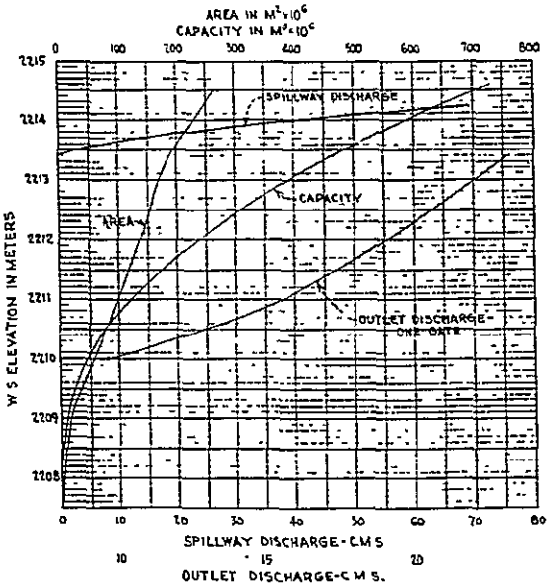
SCALE OF KILOMETERS



TYPICAL SPILLWAY SEC

POWER DIVERSION DAM





AREA - CAPACITY - DISCHARGE CURVES

FINCHAA STORAGE DAM

NOTES

All dimensions are in meters.

Reinforcement required for storage dam

The power diversion dam is located approxi

5 kilometers downstream from the stor

ETHIOPIA - UNITED STATES COOPERATIVE PROGR

FOR THE

STUDY OF WATER RESOURCES

IN COLLABORATION WITH

U.S. DEPT OF STATE AND U.S. DEPT

AGENCY FOR INT. DEV. SURVEY OF

DEPARTMENT OF WATER RESOURCES

IMPERIAL ETHIOPIAN GOVERNMENT

MINISTRY OF PUBLIC WORKS & COMMUNICA

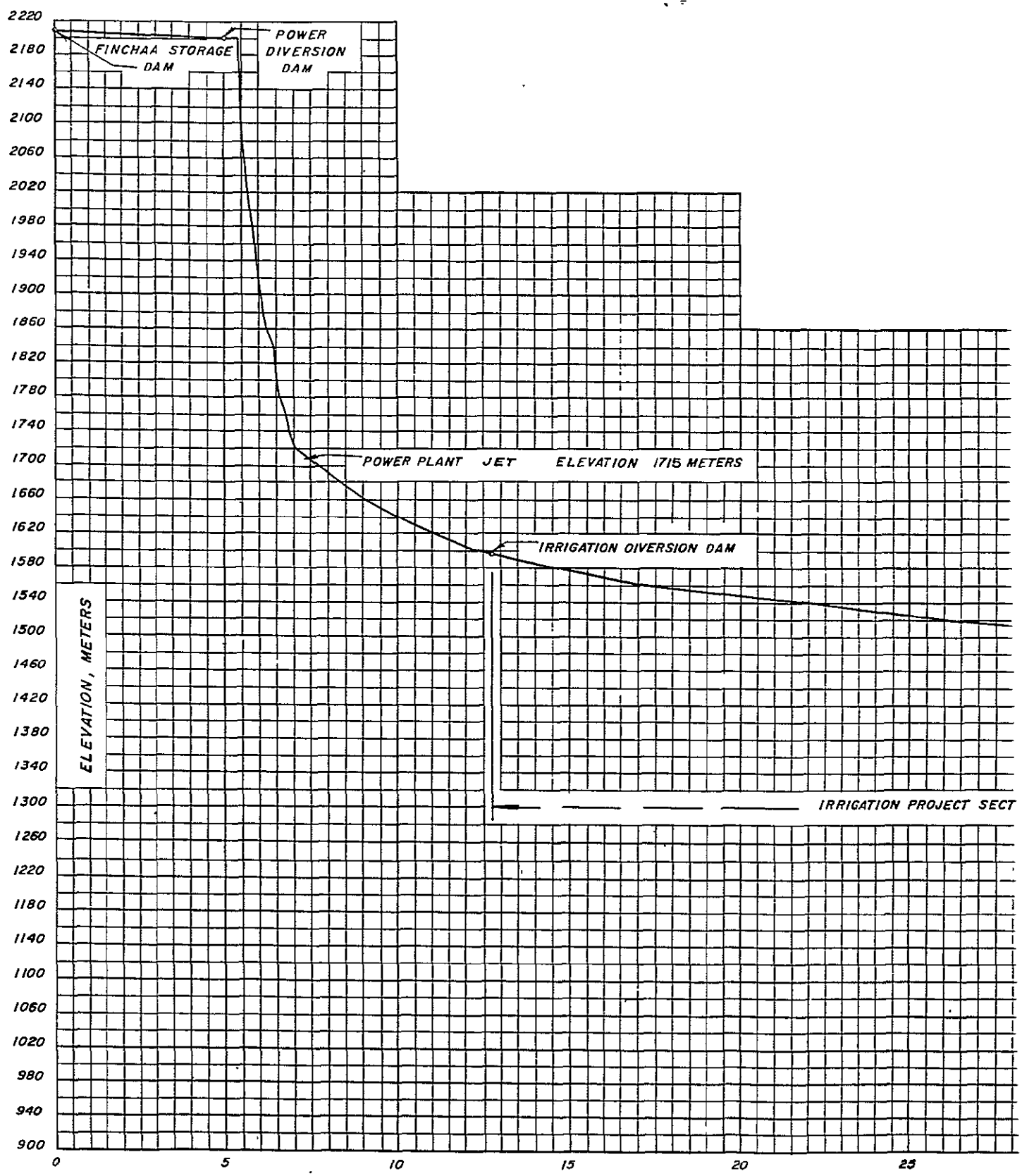
BLUE NILE RIVER BASIN

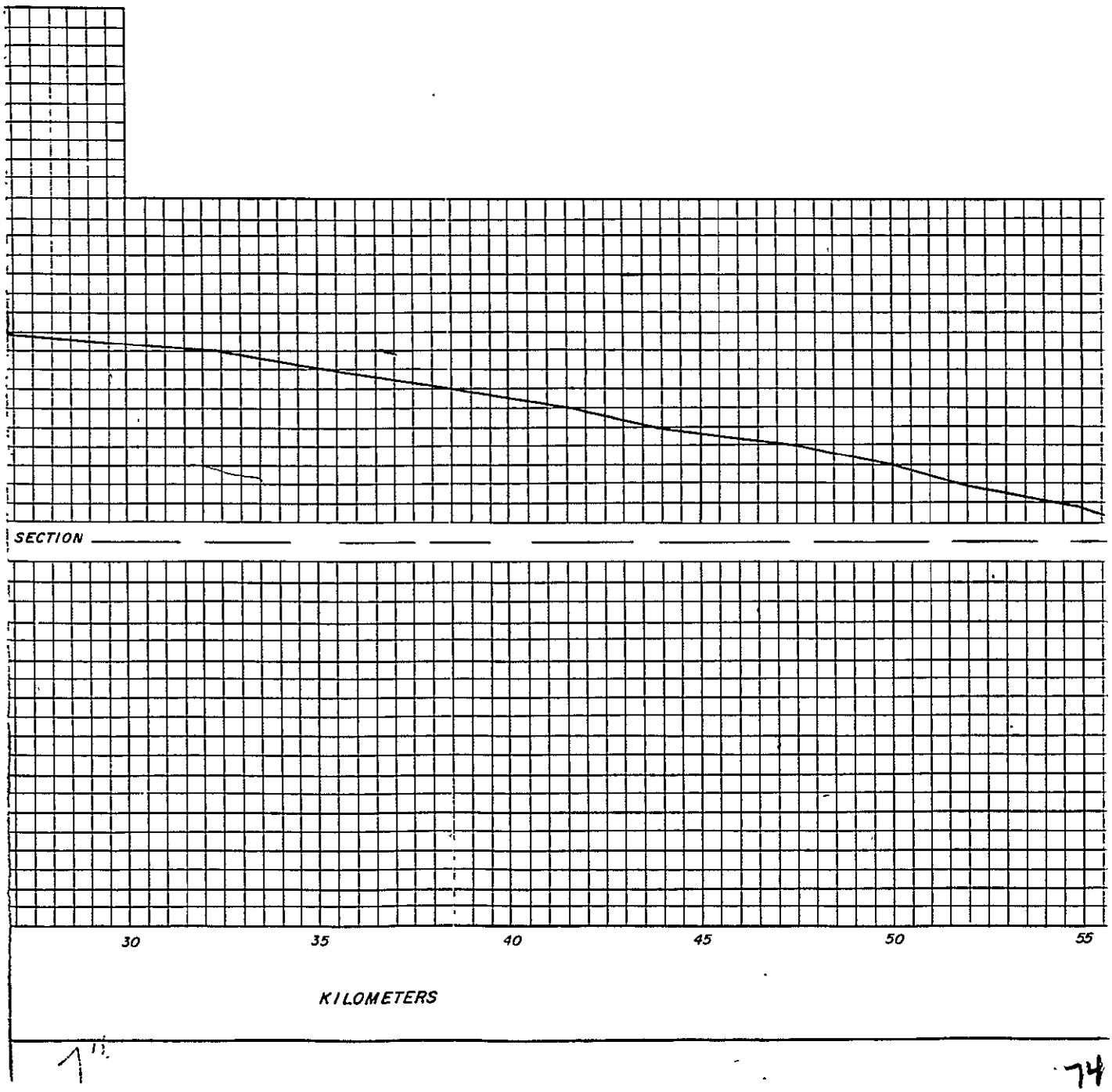
FINCHAA STORAGE DA

AND

FINCHAA POWER DIVERSION

DENVER, COLORADO. NOV 8, 1963.


FINCHAA STORAGE DAM
POWER DIVERSION DAM
POWER PLANT JET ELEVATION 1715 METERS
IRRIGATION DIVERSION DAM
IRRIGATION PROJECT SECT
ELEVATION, METERS
2220
2180
2140
2100
2060
2020
1980
1940
1900
1860
1820
1780
1740
1700
1660
1620
1580
1540
1500
1460
1420
1380
1340
1300
1260
1220
1180
1140
1100
1060
1020
980
940
900
0
5
10
15
20
25


SECTION
30
35
40
45
50
55
KILOMETERS

BEST AVAILABLE COPY

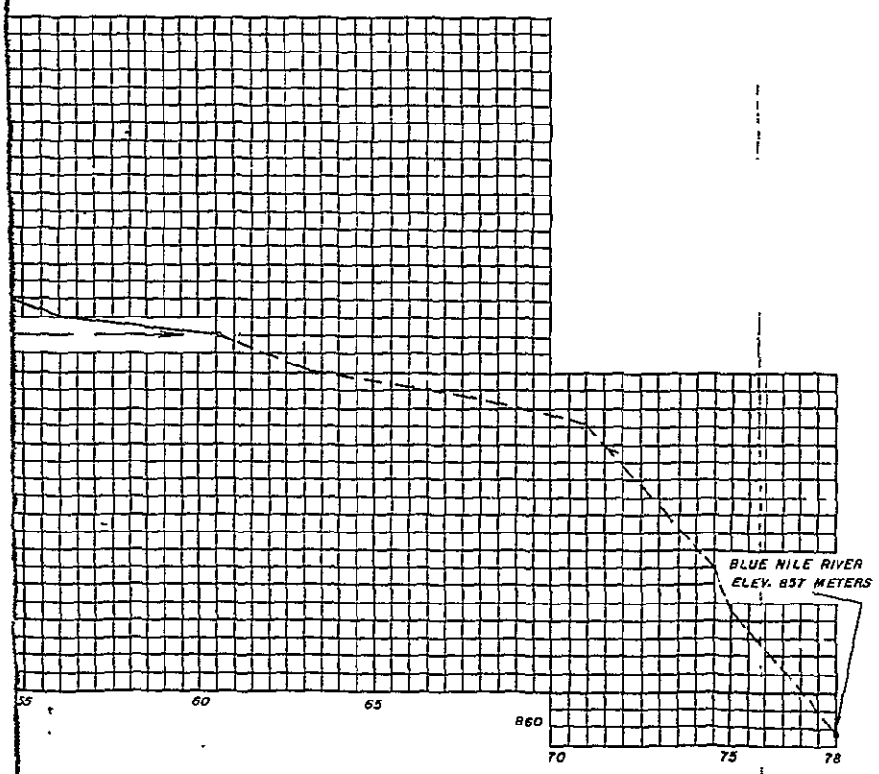
NOTES

1. Solid profile line based upon topographic data obtained by multiplex projection from aerial photographs with horizontal control by Tellurometer and vertical control by trigonometric levelling, 1962

2. Blue Nile River elevation at mouth of Finchaa River established by semi-controlled altimeter readings and by projections from elevations fixed by adjacent multiplex areas upstream and downstream from this point

3. Dashed profile line is based upon semi-controlled altimeter data.

4. Finchaa Storage Dam location at Chomen Swamp outlet.



ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH
U.S. DEPT OF STATE AGENCY FOR INT DEV AND U.S. DEPT OF INT. BUREAU OF RECLAMATION

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

PROFILE FINCHAA RIVER

CHOMEN SWAMP OUTLET TO MOL

DRAWN A.E.F.-C.L.G. SUBMITTED C.L.G.
TRACED Kerfeny Sallyne RECOMMENDED P.W.K.
CHECKED C.L.G.-G.K.A. APPROVED S.E.A.

Date Drawn DEC. 12, 1962 | 4 O-BN-7

Spillway Data

Spillway crest elevation	2213.40 m.
Inflow design flood	1,195 cu. m. per sec.
Total flood volume, 10 days	280 million cu. m.
Discharge at maximum w.s. elevation	70 cu. m. per sec.

Outlet Works. The outlet works would be located on the right abutment of the dam and would consist of two, 2.0- x 2.0-meter, slide gates with a capacity of 16 cubic meters per second at minimum water surface elevation of 2210. Stop logs have been provided for closure of the gates if required in case of emergencies or repairs to the slide gates.

Outlet Works Data

Sill elevation	2208 m.
Discharge capacity (each)--n.w.s.	23 cu. m. per sec.
Type of gate	2- x 2-m. slide gates

Reservoir. The Finchaa Reservoir would be in the Chomen Swamp, the basin of which is covered with black clay of unknown depth. It may be as much as 10 meters in depth and is believed to be underlain by volcanic rock. This soil cover forms an excellent impermeable blanket, and seepage is not considered to be a serious factor. The reservoir at normal water surface elevation would impound 464 million cubic meters of water at initial storage, covering an area of 188 square kilometers. Reservoir data are shown on Drawing No. 2.2-BN-1, and the area-capacity curve is shown on Drawing No. 2.0-Fi-1 (see SECTION III), including sediment disposition.

Site Geology

Finchaa Storage Dam. Geology at the damsites studied within the Finchaa canyon between the falls and the outlet of the swamp indicates that the foundation rock is of hard basalt which is exposed along the stream channel and generally on the sides of the valley. The soil mantle is relatively thin, perhaps up to two meters thick in local areas. The volcanic bedrock is jointed but believed to be groutable to the point that excessive leakage from the reservoir and beneath the dam can be prevented. Inasmuch as a relatively low dam will provide abundant storage and regulation, leakage is not considered to be a serious problem; however, a grout curtain under the dam at this storage site should be included in the design and cost estimates. Core trench excavation depth will average about two meters. A geologic section is shown on Drawing No. 4.0-Fi-5.

Finchaa Power Diversion Dam. Since bedrock materials are exposed at the site, required cutoff trench excavations in the stream channel and on parts of the abutments should not exceed an average depth of two meters to remove loose rock, mud seams, tree roots, and other nongroutable material along the cutoff core of the dam. Only in local areas will stripping be required to remove vegetation, such as roots of brush and large trees in the dam foundation area. A concrete or masonry-rock structure is recommended at this location. A geologic section is shown on Drawing No. 4.0-Fi-9.

Powerplant Site. The penstock tunnel will penetrate basaltic lava rock from the intake to the approximate base of the lower vertical waterfall, at which point the excavation will continue in friable sandstone to the powerplant location, where there are thick accumulations of talus, large boulders, and soil cover, probably up to 7.5 meters in depth. Beneath the talus debris the foundation for the powerplant is sandstone.

Irrigation Diversion Damsite. The irrigation diversion damsite is located below the plateau downstream from the powerplant. The foundation for the dam will be Adigrat sandstone. Canals will be common excavation in deep residual and slopewash soils over sandstone bedrock.

Construction Materials

There is abundant, good, sandy clay for impervious earth materials near the damsite. These materials are deep, residual soils, weathered from sandstone, and cover the gently rolling ridges and slopes adjacent to the damsite. No natural concrete aggregates nor pervious alluvial embankment materials were observed, and it is doubtful that any exist within an economical haul distance of the damsite. However, the hard, volcanic rock adjacent to the damsite can be quarried for rockfill, riprap, or masonry and can be crushed for concrete or mortar aggregate.

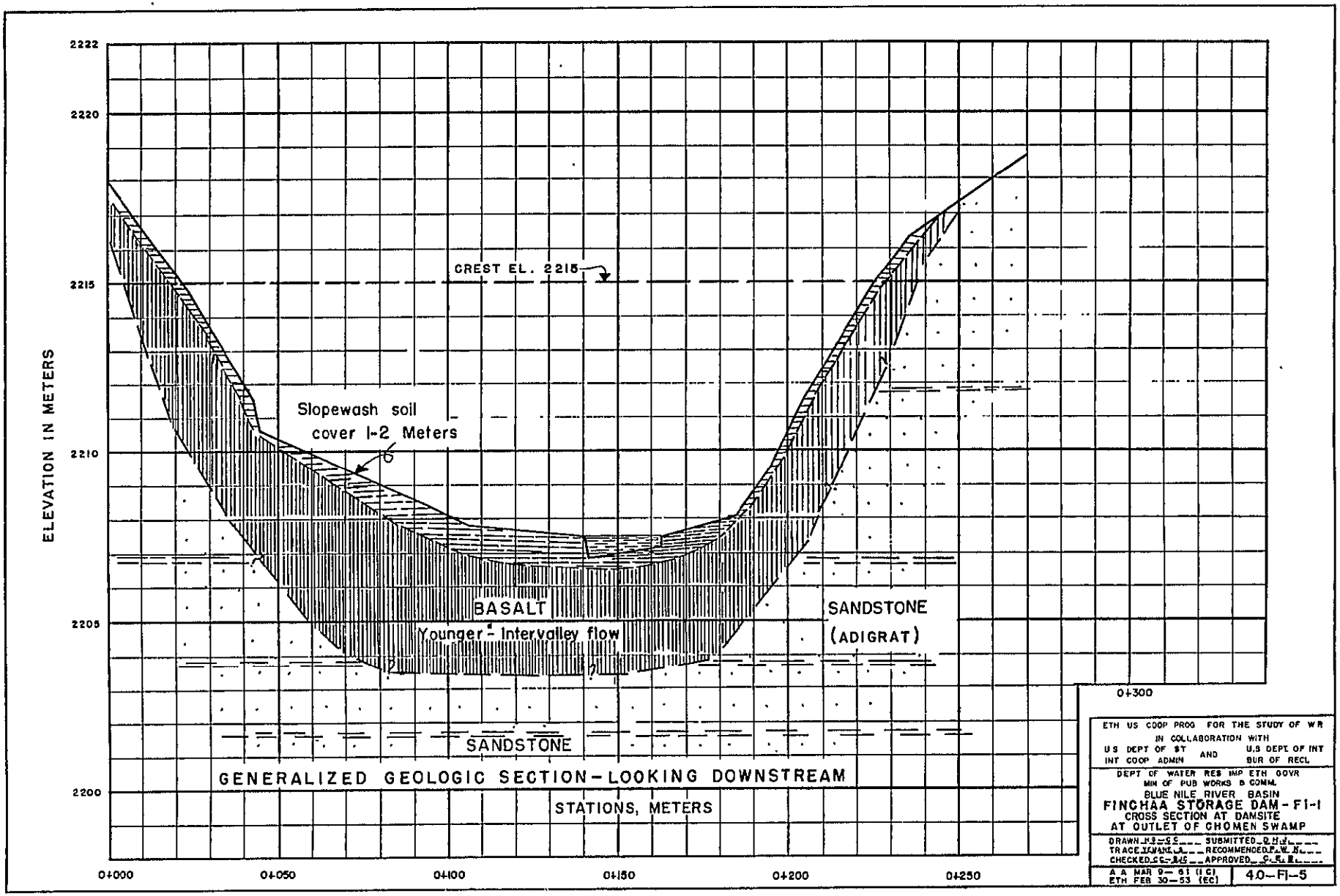
FINCHAA DAM & RESERVOIR

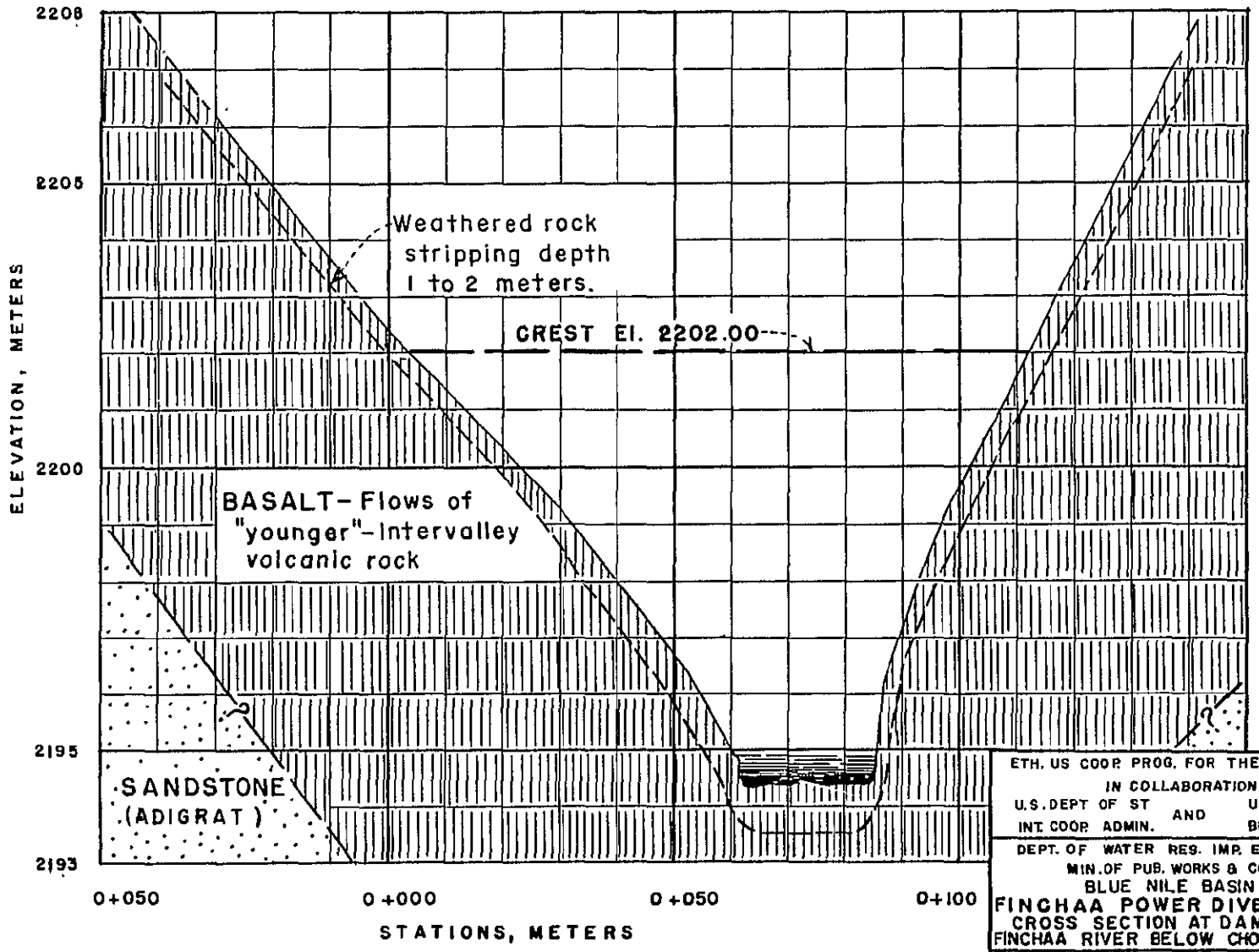
AREA CAPACITY DATA

(with sediment distributed)

CONTROL POINTS: ITEM & ALLOCATION OF STORAGE CAPACITY		DIAGRAM OF DAM	ELEVATION (METERS)	INITIAL AREA (SQ. METERS – 10^6)	CAPACITY (CUBIC METERS – 10^6): INITIAL INCREMENT	INITIAL TOTAL	WITH 50-YR. SEDIMENT INCREMENT	WITH 50-YR. SEDIMENT TOTAL
TOP OF DAM			2215.00					
MAXIMUM W.S.	FREEBOARD		2214.23	251.4		680.9		648.2
	FLOOD SURCHARGE				216.9		216.9	
NORMAL W.S.			2213.40	188.00		464.0		431.3
	ACTIVE CAPACITY				419.3		400.1	
MINIMUM OPERATING W.S.			2210.00	56.65		44.7		31.2
LIP OF LOWEST OUTLET*	INACTIVE CAPACITY		2208.00	3.70	43.3	1.4	31.2	0
	DEAD STORAGE AND SILT				1.4		0	
STREAM BED			2207.00	0		0		0

*100-YEAR SEDIMENT OF 66,000,000 M^3 WILL TAKE 2208.85 METERS ELEVATION AT THE DAM.


2222
2220
2215
2210
2205
2200
ELEVATION IN METERS
CREST EL. 2215
Slopewash soil
cover 1-2 Meters
BASALT
Younger - Intervalley flow
SANDSTONE
(ADIGRAT)
SANDSTONE
0+300
0+000
0+050
0+100
0+150
0+200
0+250
STATIONS, METERS
GENERALIZED GEOLOGIC SECTION-LOOKING DOWNSTREAM
ETH US COOP PROG FOR THE STUDY OF WR
IN COLLABORATION WITH
U S DEPT OF ST
INT COOP ADMIN
AND
U.S DEPT OF INT
BUR OF RECL
DEPT OF WATER RES IMP ETH GOVR
MIN OF PUB WORKS & COMM.
BLUE NILE RIVER BASIN
FINCHAA STORAGE DAM - FI-1
CROSS SECTION AT DAMSITE
AT OUTLET OF CHOMEN SWAMP
DRAWN H.S.-S.S. SUBMITTED Q.H.J.
TRACE J.K.WANG.A. RECOMMENDED F.W.N.
CHECKED C.C.-B.S. APPROVED C.E.B.
A A MAR 9-61 (I C)
ETH FEB 30-53 (EC)
4.0-FI-5



GENERALIZED GEOLOGIC SECTION-LOOKING DOWNSTREAM

ETH. US COOP PROG. FOR THE STUDY OF W. R.
IN COLLABORATION WITH
U.S. DEPT OF ST INT. COOP ADMIN. AND U.S. DEPT OF INT. BUR OF RECL.

DEPT. OF WATER RES. IMP. ETH. GOVR.
MIN. OF PUB. WORKS & COMM
BLUE NILE BASIN
FINCHAA POWER DIVERSION DAM
CROSS SECTION AT DAMSITE ON
FINCHAA RIVER BELOW CHOMEN SWAMP

DRAWN HG-GG SUBMITTED D.H.J.
TRACED NEGASH RECOMMENDED P.W.K.
CHECKED P.K. APPROVED C.G.B.
A.A MAR. 17-1961 40-F:-9

Access to Sites

Access to the project would have to be improved--that is, the 135 kilometers of trail from Gedo to the Finchaa damsite. This section of the road is considered for the purpose of this estimate as part of the national road system and therefore is not included as part of the project cost. However, access roads to the other project features would be necessary.

1. Road from Finchaa Dam to power diversion dam, following edge of swampy ground--five kilometers.

2. Road from power diversion dam over the escarpment to powerplant--20 kilometers.

3. Road from powerplant to irrigation diversion dam, following Finchaa River through rolling hills--five kilometers.

Power Diversion Dam

This structure is on the Finchaa River approximately 200 meters upstream from the lip of the falls. The reservoir will store 90,900 cubic meters above the minimum operating water surface elevation. It would be a masonry overflow dam with a maximum height of about 7.5 meters above river bed. The crest length includes about 40 meters for an ogee spillway section. The inlet structure for the power tunnel would be located on the right abutment and gated for emergency closure to the tunnel. See Drawing No. OA-23-101 for plan and section of dam.

Power Dam Data

Type	masonry-ogee
Volume of masonry	1,320 cu. m.
Normal water surface elevation	2200 m.
Spillway crest elevation	2200 m.
Structural height	7.5 m.
Hydraulic height	5.5 m.
Length of crest	114 m.

Power Tunnel and Penstocks

The tunnel, starting at the inlet portal near the right abutment of the power diversion dam at elevation 2195.6 meters, would be a pressure-type tunnel requiring reinforced concrete linings. It would be about 330 meters long, would be 2.2 meters in diameter, and would have a design capacity of 19 cubic meters per second. The increased hydraulic head and the poor rock formations will require a welded

steel pipe to be encased in prolongation of the tunnel for a distance of 1,210 meters, thence under cut-and-cover section for another 320 meters. Two penstocks, each having a diameter of 1.524 meters, would then be connected with butterfly valves above ground for a distance of 1,280 meters, terminating at the powerplant at elevation 1715 meters.

Tunnel Data

Type	pressure
Length	330 m.
Diameter	2.2 m.
Design capacity 1/	19 cu. m. per sec.

Welded Steel Pipe and Penstock Data

Welded Steel	
Length	1,530 m.
Diameter	2.2 m.
Design capacity	19 cu. m. per sec.
Penstocks (two)	
Length (each)	1,280 m.
Diameter (each)	1.524 m.

Powerplant

Drawing No. 4.0-BN-74 gives an indication of the river profile together with the elevations of the pertinent structures, including the powerplant. Conveyance of water from the forebay storage to the powerplant turbines would be by pressure tunnel and welded steel penstock. According to operation studies made (SECTION III), the annual gross generation would be 360,420,000 kw.-hr. for an adverse water supply period. Two generator units of 40 mw. each would be satisfactory, providing a total plant capacity of 80 mw. or 100 mv.-a. at 0.8 power factor.

Because of the high head, 467 meters (net), the two turbines will be of the impulse-type, each rated 55,725 metric hp. (56,500 English hp.) and could be double-runner with a single jet per runner. Horizontal shaft, double-overhung, single-nozzle, 429-r.p.m. wheels would be adequate. The pitch diameter of the runner would be about 208 centimeters, and the jet diameter would be about 27 centimeters. The diameter of the nozzle pipe would be about 130 centimeters with the velocity of the water through the

1/Designs permit meeting annual load factor at plant of 58%.

nozzle pipe inlet determined to be about 8.5 meters per second. The width of the wheel pit would be slightly over three meters, and the flow of water to the turbines would be controlled by a needle valve from governor action related to load demand. The governor action would also simultaneously operate a pressure regulator to by-pass water from the penstock, during load changes, around the turbine into the tailrace. Energy absorbers are required to dissipate water from the pressure regulators. Thus, there will be no sudden changes in the velocity of the water in the tunnel and penstocks due to load pick-up or rejection.

The two generators would have individual step-up transformers, as shown by Drawing No. 4.0-Fi-8, from 13.8-kv. generator voltage to 161-kv. transmission voltage, each transformer rated 50,000 kv.-a. Generator units 1 and 2 will provide station service power, stepping from 13.8-kv. to 220-volt, three-phase, by means of a 300-kv.-a. transformer connected to each unit, electrically interlocked so that only one transformer is energized at one time. This source will also serve the caretakers' and operators' quarters. The switchyard is to be arranged so that future 45-kv. and 12.47-kv. lines can be terminated.

Summarizing, the generators would have the following characteristics.

Speed	429 r.p.m.
Number of poles	14
Horizontal shaft, direct connected	
Voltage (wye connected)	13.8 kv.
Frequency	50 cycles
Power factor, variable, 0.8 thru unity, lag or lead	

Transmission Plant

Transmission Lines. Assuming that the Finchaa powerplant will be the first Blue Nile plant to serve the Addis Ababa Complex, followed next by the Neshe powerplant (30 km. from the Finchaa powerplant), a double-circuit, steel tower, transmission line with one circuit installed initially and rated at 161 kv. would be constructed simultaneously with the Finchaa powerplant from the Dongi Substation, 1/ located on the escarpment above the powerplant, to Addis Ababa. Later, the second circuit would be installed on these existing towers when the Neshe powerplant is constructed, thus completing the double-circuit line. A 1.8-kilometer, single-circuit, steel tower line would be required from the Finchaa switchyard to Dongi Substation.

1/Named after the lower section of Chomen Swamp, known as Dongi Swamp to the local people.

Prior to construction of Neshe, there will be about 249.8 km. of 161-kv. line, consisting of 1.8 kilometers of single-circuit tower construction joining the 248 km. of double-circuit tower construction carrying one circuit. The junction point would be the future site of the Dongi Substation, required when Neshe is constructed.

The transmission distance (airline) from Addis Ababa to the Finchaa powerplant would be about 170 kilometers (100 miles) and would cross some very rough and nearly inaccessible terrain. Access to a line along this route would be a serious problem and almost prohibitive in cost. For these reasons, the routing shown on Drawing No. 4.0-BN-170 (SECTION VII)--generally south along the east side of the swamp toward Gedo and thence along the main highway to Addis Ababa--may be the most feasible at this time, even though 240 kilometers (150 miles) in length. The latter route can presently be traveled all year from Addis Ababa to Gedo but only during the dry season from Gedo to the edge of the escarpment overlooking the powerplant below.

The transmission line will provide satisfactory service using 954,000 circular mil ASCR conductor based upon USBR standards, although some utilities might consider that 795,000 circular mil would be adequate. Cost estimates here, however, are based upon using 954,000 circular mil ACSR.

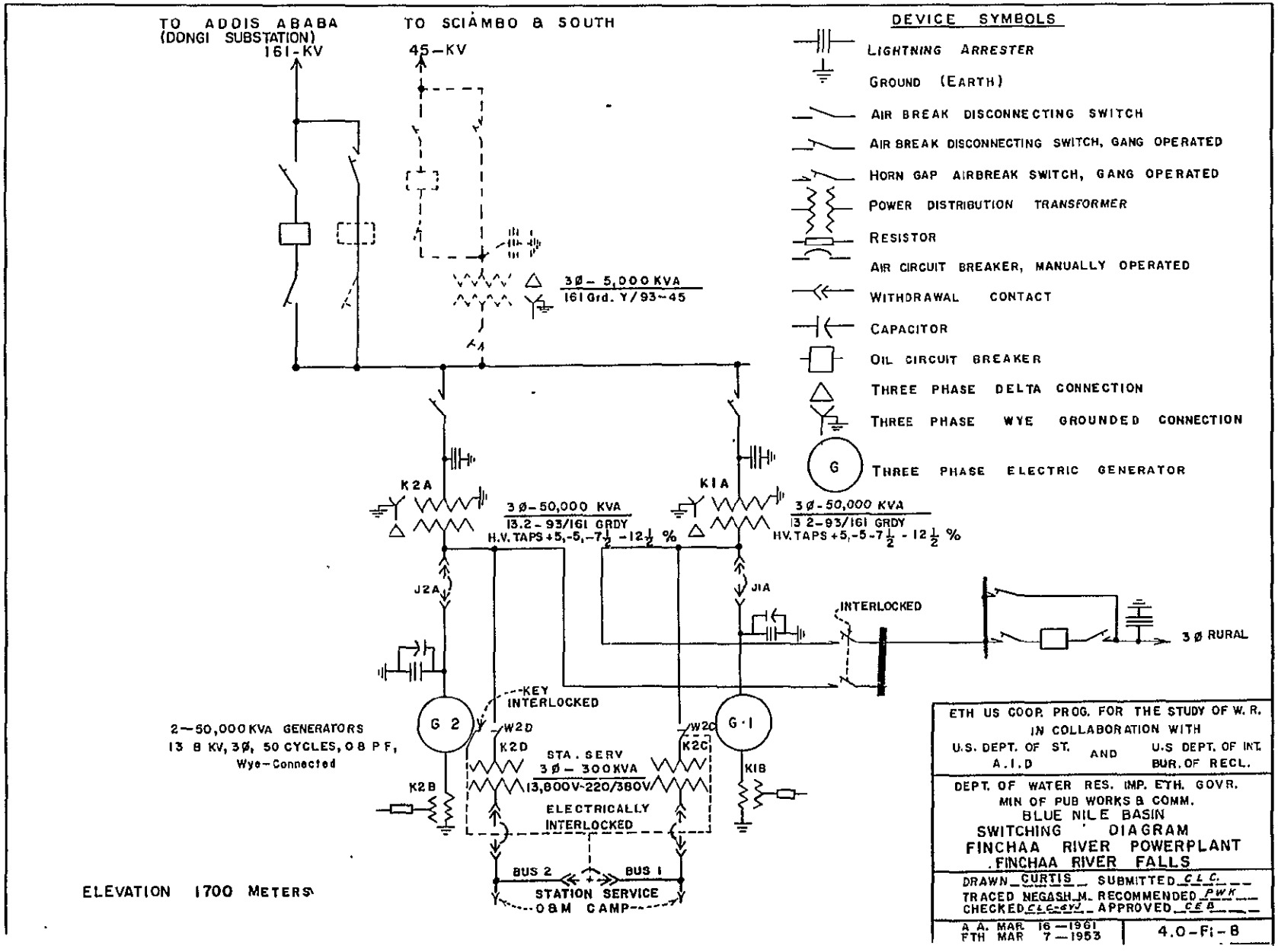
A 230-kv. line was avoided because at some of the altitudes the line will traverse, corona loss would require larger conductors resulting in higher cost. Also, the higher voltage was avoided for operational reasons, as the highest voltage used so far is 132 kv. The special problems associated with 230 kv. should be avoided at the present stage of electrification.

Impregnated eucalyptus poles were considered for two separate 161-kv. lines, but they were decided against at this time for the following reasons:

1. Lack of experience data concerning service lives of these treated poles.

2. The annual prevalent practice of burning off the bush after the end of the rains may cause destruction of some of the wood-pole structures.

Steel tower lines, although requiring greater initial investment, may have lower annual costs because of the higher OM&R for the wood-pole lines. Until the reliability of the treated eucalyptus poles is demonstrated by successfully resisting dry rot and termites, steel was the choice for this project.


TO ADDIS ABABA
(DONGI SUBSTATION)
161-KV
TO SCIAMBO & SOUTH
45-KV
3Ø- 5,000 KVA
161 Grd. Y/93-45
DEVICE SYMBOLS
LIGHTNING ARRESTER
GROUND (EARTH)
AIR BREAK DISCONNECTING SWITCH
AIR BREAK DISCONNECTING SWITCH, GANG OPERATED
HORN GAP AIRBREAK SWITCH, GANG OPERATED
POWER DISTRIBUTION TRANSFORMER
RESISTOR
AIR CIRCUIT BREAKER, MANUALLY OPERATED
WITHDRAWAL CONTACT
CAPACITOR
OIL CIRCUIT BREAKER
THREE PHASE DELTA CONNECTION
THREE PHASE WYE GROUNDED CONNECTION
G
THREE PHASE ELECTRIC GENERATOR
K2A
K1A
3Ø-50,000 KVA
13.2-93/161 GRDY
H.V. TAPS +5,-5,-7½ -12½ %
3Ø-50,000 KVA
13.2-93/161 GRDY
H.V. TAPS +5,-5-7½ - 12½ %
J2A
J1A
INTERLOCKED
3Ø RURAL
KEY
INTERLOCKED
2-50,000 KVA GENERATORS
13.8 KV, 3Ø, 50 CYCLES, 0.8 P.F.
Wye-Connected
G 2
G-1
W2D
W2C
K2D
K2C
STA. SERV
3Ø- 300 KVA
13,800V-220/380V
K2B
K1B
ELECTRICALLY
INTERLOCKED
BUS 2
BUS 1
STATION SERVICE
O&M CAMP
ELEVATION 1700 METERS
ETH US COOP. PROG. FOR THE STUDY OF W. R.
IN COLLABORATION WITH
U.S. DEPT. OF ST. A.I.D
AND
U.S DEPT. OF INT. BUR. OF RECL.
DEPT. OF WATER RES. IMP. ETH. GOVR.
MIN OF PUB WORKS & COMM.
BLUE NILE BASIN
SWITCHING DIAGRAM
FINCHAA RIVER POWERPLANT
FINCHAA RIVER FALLS
DRAWN CURTIS SUBMITTED C.L.C.
TRACED NEGASH M. RECOMMENDED PWK
CHECKED CLC-GVJ APPROVED CEB
A.A. MAR. 16-1961
ETH MAR 7-1953
4.0-Fi-8

Provisions have been made for future facilities to serve local loads, although it is believed that it will not be possible to serve rural areas for many years as it has been proven elsewhere that developing countries in early stages of electrification cannot afford rural electrification. Therefore, delivery of the entire net plant output will undoubtedly be utilized in the Addis Ababa Complex, or possibly in addition at some of the larger urban centers within transmission distance. (These two cases have been studied; see SECTION VII.)

Concerning a long-range development program to provide electricity for the Chomen Swamp area, a 45-kv. line around the north and west sides of the swamp, serving Shambo, Haratu, and Gedo, may eventually be justified. The distance is 110 km. (66 miles). Ultimately, with increased loads, a 161/45-kv. substation can be installed at Gedo, completing a loop. The same substation could supply Lekkemt at 45-kv.

Substation. By 1971, EELPA will have constructed the Sebeta (Sabata) and Gafarsa Substation No. 1 west of Addis Ababa as part of a basic plan to provide a 132-kv. ring bus around the city. (See Dwg. No. 4.0-Et-14, SECTION VII.) The 161-kv. lines from the Finchaa Sub-Basin powerplants can either terminate in 161- and 132-kv. additions to Gafarsa Substation No. 1 or in a separate substation which can eventually be expanded to include 230-kv. in the future. Since there might be an advantage in having another substation as part of the ring bus extension located to the north or northeast of the center of the city, a separate substation identified as Gafarsa No. 2 has been used for estimating purposes, as shown by Drawing No. 4.0-BN-174 with the 1980 system shown on Drawing No. 4.0-Et-15 (SECTION VII).

The substation will be of the outdoor type with controls and service equipment located indoors. One control house and one combination service building-warehouse will be necessary. A double-bus, single-breaker scheme with one transfer breaker per voltage section is used, but the latter breaker is installed only when warranted. Connections are made according to American practice, which uses one main and one auxiliary bus whereas the European practice uses two main buses. Construction costs of both arrangements are about equal and both types have advantages. Since costs are about equal, the American practice is used here, as a major purpose of designs at this reconnaissance stage is to arrive at approximate estimates of cost. Ultimately, when these facilities are investigated and designed for final construction, such designs may well follow European practice. These conditions also apply to powerplant switchyards. Standard A.S.A. electrical symbols are used as portrayed by Drawing No. 4.0-BN-23.

The terminal facilities required in the receiving-end substation, Gafarsa No. 2, for the first 161-kv. line (from Finchaa powerplant) will consist of a 161-kv. line bay, transformer bay, 161/132-kv. autotransformer bay, and three 132-kv. bays (two-line bays) as explained by Note 1 on Drawing No. 4.0-BN-174. These facilities have been designated as Stage 01.

Irrigation Diversion Dam

The irrigation diversion damsite would be located on the Finchaa River approximately 11 kilometers downstream from the powerplant. There would be no significant amount of storage in the diversion reservoir. Headworks for two radial gates would be provided, one for the East Main Canal designed to discharge 10.5 cubic meters per second, the other for a flow of 8.5 cubic meters per second with a sluiceway for each headworks for sediment disposition. The ogee-type spillway envisioned for this dam is estimated to be 210 meters in length.

Irrigation Diversion Dam Data

Volume of masonry	2,650 cu. m.
Maximum water surface elevation	1602.25 m.
Normal water surface elevation	1600.5 m.
Structural height	3.5 m.
Elevation at top of dam	1602.6 m.
Maximum flood discharge	900 cu. m. per sec.
Crest length	292 m.

Main Canals

Two main canals starting from the outlet works of the diversion dam on each side of the river have been planned for the project to convey water by gravity to serve as much as possible of the lands determined to be arable. The location would traverse rolling hills and cross many ravines and draws which will require suitable structures to accommodate the high flows of the rainy season. The proposed route would be for the most part in the fairly deep soils of the valley, but short reaches might possibly be in sandstone where soil cover is thin or entirely absent. No problem should be encountered from constructing the canal as an open, unlined section. Clearing will be a definite problem, present vegetation varying from dense growths of large trees in many areas to scattered trees with tall grasses. Structures such as bridges, culverts, wasteways, turnouts, siphons, checks, and drops would have to be provided as required. The cost of these structures has been estimated, using the Upper Guder Project as a prototype, on the assumption that it closely approximates the structure requirements for the Finchaa Project.

86

Capacitor potential device

Bushing potential device

Lightning arrester

Capacitor

Ground (earth) connection

Potential transformer

Current transformer, wound type

Current transformer, bushing type

Disconnecting switch, gang operated

Horn gap airbreak switch, gang operated

Disconnecting switch, motor operated

Oil circuit breaker

Air circuit breaker, manually operated

Withdrawal contact

Fuse

Resistor

G Generator

Cable pothead

Electrical connection

No connection

Power transformer

3 ϕ, Wye grounded connection

3 ϕ, Delta connection

3 ϕ, Zigzag connection

Auto transformer

Fused disconnecting switch

Interrupter switch

Carrier current wave trap

Disconnecting switch, hook-stick operated

S Synchronous condenser

Base upon A.S.A. Graphical symbols

ETH-US COOP PROG. FOR THE STUD. OF WATER R
IN COLLABORATION WITH
U.S. DEPT OF ST AGENCY FOR INT.DEV. AND U.S DEPT OF INT BUR. OF RECL

DEPT OF WATER RES. IMP. ETH GOVERNMENT
MIN. OF PUB WORKS & COMM
BLUE NILE RIVER BASIN

RECONNAISSANCE DESIGNS
DEVICE DESIGNATIONS - SYMBOLS FOR SWITCHING DIAGRAMS

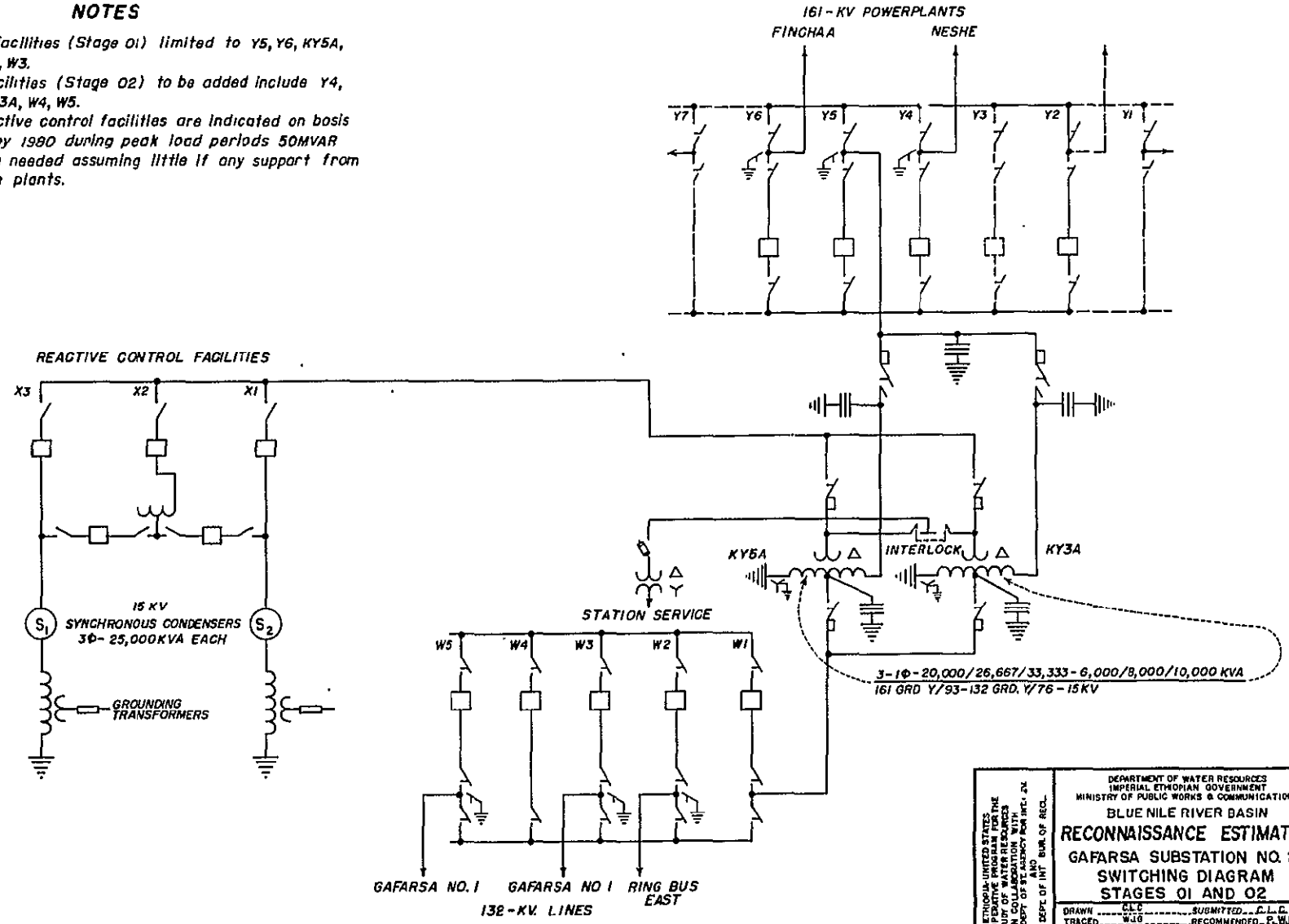
DRAWN C.L. Cyrus SUBMITTED C.L.C.
TRACED Gabra Christos RECOMMENDED P.W.K.
CHECKED C.L.C. APPROVED C.E.B.

A A Mar. 14 - 1962 (I C)
ETH. Mar 5 - 1954 (E C)

4-O-BN-23

NOTES

1. Finchaa facilities (Stage 01) limited to Y5, Y6, KY5A, W1, W2, W3.
2. Neshe facilities (Stage 02) to be added include Y4, Y2, KY3A, W4, W5.
3. Some reactive control facilities are indicated on basis that by 1980 during peak load periods 50MVAR will be needed assuming little if any support from Awash plants.



APPROXIMATE ELEVATION 2560 METERS

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES UNDER SECTION 104 (b) OF PL 480 AND U.S. DEPT. OF INT. BUR. OF REC.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

RECONNAISSANCE ESTIMATES

GAFARSA SUBSTATION NO. 2
SWITCHING DIAGRAM
STAGES 01 AND 02

DRAWN	C.L.C.	SUBMITTED	C.L.C.
TRACED	W.J.G.	RECOMMENDED	P.W.K.
CHECKED	C.L.C.	APPROVED	C.E.R.

Addis Ababa Ethiopia NOVEMBER 13, 1963

4.0-BN-174

East Main Canal. The East Main Canal would originate at the discharge end of the outlet works on the right abutment of the irrigation diversion dam. It would extend in a northerly direction for a distance of approximately 56.7 kilometers and would have an initial capacity of 10.2 cubic meters per second. This canal would convey water by gravity to serve approximately 8,000 hectares of irrigable lands.

East Main Canal Data

Length	56.7 km.
Type	unlined
Initial capacity	10.2 cu. m. per sec.
Initial water surface elevation	1600 m.

West Main Canal. The West Main Canal would extend from the discharge end of the outlet works, on the left abutment of the irrigation diversion dam. It would proceed in a northerly direction for a distance of approximately 43.1 kilometers and would have an initial capacity of 8.5 cubic meters per second. The canal would convey water by gravity to serve approximately 7,000 hectares of irrigable land on the west side of the Finchaa River.

West Main Canal Data

Length	43.1 km.
Type	unlined
Initial capacity	8.5 cu. m. per sec.
Initial water surface elevation	1600 m.

Distribution System and Drains

Distribution System. The irrigable lands occur on broad-topped ridges varying in width from 300 to 1,000 meters with slopes of one to two percent, lending themselves readily to water-spreading with a minimum expense of land leveling, increasing in slope on the sides of the ridges up to 12 percent. Distribution of water to the lands with the steeper gradients will be more difficult and costly to develop than those on the plateaus, with particular attention necessary for the prevention of erosion. The distribution system for the 15,000 hectares of irrigable lands is envisioned as an open, unlined canal with sufficient capacity to meet the peak demand of any lateral service area during the period of maximum demand. The distribution system has been planned on the basis that the application of water for the area would be on a continuous 24-hour operation when required, based on a rotation system of irrigation. Included in the cost estimate are farm turnouts that would be provided for about every 17 hectares of land, with metal slide gate and meter-type

measuring devices leading to a concrete pipe. Other structures required would include drops, checks, culverts, and farm crossings. Costs for the distribution system were computed on a cost per hectare basis derived from semidetailed studies performed on the Upper Birr Project. The estimated cost of Eth$330 per hectare was used, which excludes contingencies, engineering, and general expense.

Drains. Costs have been estimated for construction of surface drainage to be provided for removal of irrigation waste and excess precipitation falling on the irrigable lands. The erosiveness of the soils and the fast slope of the lands are such that without proper drainage the erosion would develop numerous, deep, vertically walled drainageways that would wash away the soil resources. The natural drainage channels would be used for outlet purposes wherever practicable and would be protected and improved wherever necessary or desirable. Based upon the Upper Birr Project, where semidetailed studies were performed, the cost per hectare was estimated to be Eth$120 on the assumption that the natural drainage channels were more numerous than those of the prototype, and excluding contingencies, engineering, and general expense.

Estimates for subsurface drainage requirements were not possible because of lack of data. Further studies to determine the requirements and feasibility of subsurface drains would include existing water table behaviour, any subsurface obstructions such as dikes that would impound water, an evaluation of present vegetation for evidence of wet areas, and suitable pump-in tests to determine the in-place permeability. It is emphasized that if subsurface drainage is found necessary, the cost would add a significant amount to the total project cost.

Service Facilities

Housing and administrative buildings will be required by government personnel to administer and oversee that the construction of the features follows the contract specifications and later to house operation and maintenance personnel. Cost generally associated with this item includes camps, construction roads and trails, utility systems, transportation equipment, and cost of temporary plant used during construction. The estimates for this item, in the absence of local data, were based on United States Bureau of Reclamation practices modified to local requirements. Generally, cost per square meter was employed, using prices prevailing in Addis Ababa for construction of the various buildings estimated to be required.

Estimates of Construction Cost

The total construction cost for the multipurpose Finchaa Project is estimated at Eth$86,127,000 on the basis of January 1961

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN—ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project FINCHAA--Multiple-purpose

Date of Estimate November 1963 — Currency in terms of Ethiopian Dollars

Prices as of January 1961 — (U S $ 1.00 = Eth $ 2.50)

ITEM NO	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	FINCHAA PROJECT--Multiple-purpose					71,740,500	86,127,000
	Joint-use features					(3,893,200)	(4,838,000)
	Power features					(54,940,400)	(65,177,000)
	Irrigation features					(12,906,900)	(16,112,000)
	FINCHAA STORAGE DAM--Stone masonry dam with 50 meter ogee spillway; crest length, 210 meters; height of dam 6.4 meters. Joint-use. Dwg. OA-23-101					568,200	682,000
1	Diversion and care of river	Lump Sum		Lump Sum	9,400		
2	Excavation, common	1,400	m^3	1.95	2,730		
3	Excavation, rock	340	m^3	8.00	2,720		
4	Pressure grouting, all work and material	Lump Sum		Lump Sum	26,700		
5	Masonry in abutments	2,115	m^3	70.00	148,050		
6	Masonry in spillway	1,300	m^3	70.00	91,000		
7	Concrete in spillway crest and bucket	160	m^3	180.00	28,800		
8	Concrete in outlet works	215	m^3	210.00	45,150		
9	Reinforcement	13,000	kg	1.00	13,000		
10	Drilling drainage holes	140	lm	25.00	3,500		
11	Drainage pipe, concrete 10 cm diameter	120	lm	12.60	1,512		
12	Drainage pipe, concrete 20 cm diameter	20	lm	21.00	420		
13	Handrail, 0.05 m. diameter	988	kg	2.60	2,569		
14	Slide gates, 2 - 2.0 X 2.0 m, cast iron and motor operated hoists	14,370	kg	5.50	79,035		
	Subtotal				454,586		
	Contingencies (25±%)				113,614		
	Field Cost--Finchaa Storage Dam				568,200		
	Engineering and General Expense (20±%)				113,800		
	Total est. const. cost--Finchaa Storage Dam				682,000		
	POWER DIVERSION DAM--Stone masonry dam with 40 meter ogee spillway; crest length, 114 meters; height of dam 7.5 meters Dwg. OA-23-101					174,600	210,000
1	Diversion and care of river	Lump Sum		Lump Sum	2,000		
2	Excavation, rock	800	m^3	8.00	6,400		
3	Masonry in spillway	790	m^3	70.00	55,300		
4	Masonry in abutments	530	m^3	70.00	37,100		
5	Concrete in spillway crest and bucket	130	m^3	180.00	23,400		
6	Pressure grouting, all work and material	Lump Sum		Lump Sum	15,500		
	Subtotal				139,700		
	Contingencies (25±%)				34,900		
	Field Cost--Power Diversion Dam				174,600		
	Engineering and General Expense (20±%)				35,400		
	Total est. const. cost--Power Diversion Dam				210,000		
	IRRIGATION DIVERSION DAM--Stone masonry dam with 210 meter ogee spillway; crest length, 292 meters; height of dam, 3.5 meters					454,000	545,000
1	Diversion and care of river	Lump Sum		Lump Sum	15,000		
2	Excavation, common, for weir and structures	14,700	m^3	1.95	28,665		
3	Excavation, rock for weir and structures	7,000	m^3	8.00	56,000		
4	Masonry in weir	2,400	m^3	70.00	168,000		
5	Masonry in abutments	250	m^3	70.00	17,500		
6	Concrete in headworks and sluiceways	174	m^3	210.00	36,540		
7	Pressure grouting foundations	292	lm	83.00	24,236		
8	Gates, gate hoists, handrails and etc.	Lump Sum		Lump Sum	17,200		
	Subtotal				363,141		
	Contingencies (25±%)				90,859		
	Field Cost--Irrigation Diversion Dam				454,000		
	Engineering and General Expense (20±%)				91,000		
	Total est. const. cost--Irr. Diversion Dam				545,000		

TABLE V-1

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN-ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project FINCHAA--Multiple-purpose

Date of Estimate November 1963

Currency in terms of Ethiopian Dollars

Prices as of January 1961

(U S $ 1 00 = Eth $ 2 50)

ITEM NO	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	TUNNEL AND PENSTOCKS--Diameter 2.2 meters; 330 meter reinforced conc. lined tunnel, 880 meter penstock in tunnel, 320 meter penstock in cut and cover. Two barrels, penstock diameter 1.524 meters, length 1280 meters, above ground. Max. head 536 meters. Plate thickness, 22.2 to 38.1 mm.					28,650,800	32,948,000
1	Excavation, all classes in open cut	12,500	m^3	3.25	40,625		
2	Excavation, tunnel	9,850	m^3	120.00	1,182,000		
3	Backfill, select, cut and cover section	11,300	m^3	2.50	28,250		
4	Concrete in tunnel lining	512	m^3	238.00	121,856		
5	Concrete behind penstock in tunnel	6,830	m^3	150.00	1,024,500		
6	Reinforcement in tunnel lining	43,500	kg	1.12	48,720		
7	Tunnel supports and lagging	Lump Sum		Lump Sum	284,000		
8	Grouting and drainage	Lump Sum		Lump Sum	213,000		
9	Steel penstocks, above and below ground	5,193,500	kg	3.43	17,813,705		
10	Piers and anchorages for penstocks	Lump Sum		Lump Sum	1,794,000		
11	Butterfly valves and controls, 2-1.68 m dia.	69,100	kg	4.12	284,692		
	Tunnel Intake Structure						
12	Excavation, common	140	m^3	1.95	273		
13	Excavation, rock	50	m^3	8.00	400		
14	Fill, misc. rock, access to structure	1,252	m^3	5.75	7,199		
15	Concrete in superstructure	90	m^3	210.00	18,900		
16	Concrete in substructure	130	m^3	150.00	19,500		
17	Reinforcement	11,700	kg	1.00	11,700		
18	Masonry in retaining walls	40	m^3	70.00	2,800		
19	Trashracks and miscellaneous metalwork	2,500	kg	2.60	6,500		
20	Slide gate, 2.2 X 2.2 meters	6,000	kg	3.00	18,000		
	Subtotal				22,920,620		
	Contingencies (25±%)				5,730,180		
	Field Cost--Tunnel and Penstocks				28,650,800		
	Engineering and General Expense (15±%)				4,297,200		
	Total est. const. cost--Tunnel and Penstocks				32,948,000		
	IRRIGATION CANALS--Unlined					4,015,400	5,020,000
	East Main Canal and Laterals over 1.0 cu. meters/sec. Length, 101.1 kms; capacity, 10.5 to 1.0 cu. meters/sec.					(2,424,600)	(3,031,000)
1	Canal excavation, common	782,370	m^3	0.82	641,543		
2	Canal excavation, rock	15,970	m^3	8.00	127,760		
3	Compacting embankment	204,610	m^3	0.98	200,518		
4	Structures, concrete and masonry	Lump Sum		Lump Sum	814,650		
5	Gates, hoists, valves and miscellaneous metalwork	Lump Sum		Lump Sum	19,400		
6	Concrete pipe	Lump Sum		Lump Sum	38,800		
7	Other miscellaneous work	Lump Sum		Lump Sum	96,980		
	Subtotal				1,939,651		
	Contingencies (25±%)				484,949		
	Field Cost--East Main Canal				2,424,600		
	Engineering and General Expense (25±%)				606,400		
	Total est. const. cost--East Main Canal				3,031,000		

TABLE V-1

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN—ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project FINCHAA--Multiple-purpose

Date of Estimate November 1963

Prices as of January 1961

Currency in terms of Ethiopian Dollars

(U S $ 1 00 = Eth $ 2 50)

ITEM NO	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	IRRIGATION CANALS--Unlined (Continued)						
	West Main Canal and Laterals over 1.0 cu. meters/sec. Length, 73.9 kms; capacity, 8.5 to 1.2 cu. meters/sec.					(1,590,800)	(1,989,000)
1	Canal excavation, common	514,740	m^3	0.82	422,087		
2	Canal excavation, rock	10,500	m^3	8.00	84,000		
3	Compacting embankment	132,870	m^3	0.98	130,213		
4	Structures, concrete and masonry	Lump Sum		Lump Sum	534,500		
5	Gates, hoists, valves and miscellaneous metalwork	Lump Sum		Lump Sum	12,700		
6	Concrete pipe	Lump Sum		Lump Sum	25,500		
7	Other miscellaneous work	Lump Sum		Lump Sum	63,630		
	Subtotal				1,272,630		
	Contingencies (25±%)				318,170		
	Field Cost--West Main Canal				1,590,800		
	Engineering and General Expense (25±%)				398,200		
	Total est. const. cost--West Main Canal				1,989,000		
	IRRIGATION DISTRIBUTION SYSTEM--Open lateral, unlined system for 15,000 net hectares on both sides of the Finchaa River					6,187,500	7,734,000
1	Finchaa Project distribution system	15,000	ha	330.00	4,950,000		
	Contingencies (25±%)				1,237,500		
	Field Cost--Distribution system				6,187,500		
	Engineering and General Expense (25±%)				1,546,500		
	Total est. const. cost--Distribution system				7,734,000		
	DRAINAGE SYSTEM--Open-land drains for 15,000 net hectares of irrigated land					2,250,000	2,813,000
1	Finchaa Project drains	15,000	ha	120.00	1,800,000		
	Contingencies (25±%)				450,000		
	Field Cost--Drains				2,250,000		
	Engineering and General Expense (25±%)				563,000		
	Total est. const. cost--Drains				2,813,000		
	POWERPLANT--Hydro.					8,812,000	11,015,000
1	Structures and improvements, masonry and reinforced concrete	Lump Sum		Lump Sum	1,800,000	(1,800,000)	
	Waterways						
2	Tailrace excavation, common	Lump Sum		Lump Sum	162,000	(162,000)	
3	Turbines and generators--Two units 50,000 KVA, 13.2 KV, 0.8 pf, 50 cycle generators and 56,500 hp, 429 rpm, 467 meter head impulse type horizontal turbines	Lump Sum		Lump Sum	4,800,000	(4,800,000)	
4.	Accessory electrical equipment--All equipment required for control and protection of generators and station service power	Lump Sum		Lump Sum	1,100,000	(1,100,000)	
5	Miscellaneous equipment--Required for general station use	Lump Sum		Lump Sum	700,000	(700,000)	
6	Access road--Two lane crushed rock from Irr. Div. Dam to Powerplant	5	kms	40,000.00	200,000	(250,000)	
	Contingencies (25±%)				50,000		
	Engineering and General Expense (25±%)						(2,203,000)

TABLE V-1

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN—ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project FINCHAA—Multiple-purpose

Date of Estimate November 1963

Prices as of January 1961

Currency in terms of Ethiopian Dollars

(U S $ 1 00 = Eth $ 2 50)

ITEM NO	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	TRANSMISSION LINES, SWITCHYARDS AND SUBSTATIONS					17,303,000	21,004,000
1	Finchaa switchyards—Located near powerplant					(1,863,000)	
	Single breaker line bay, 161 KV, 1,200 ampere, complete	Lump Sum		Lump Sum	300,000		
	Single bay 161 KV, 1,200 ampere switch installations only.	Lump Sum		Lump Sum	100,000		
	Single breaker line bay 15 KV, complete	Lump Sum		Lump Sum	32,000		
	Transformers, two required, three-phase, 50,000 KVA, 13.2-93/161-KV installation complete	Lump Sum		Lump Sum	1,431,000		
	Engineering and General Expense (25±%)						(465,500
2	Transmission line—Finchaa Switchyard to Dengi Substation 161 KV, single-circuit steel towers with one overhead ground wire and three 954 MCM ACSR conductors. Rough terrain, much clearing.	1.8	kms	50,000.00	90,000	(90,000)	
	Engineering and General Expense (20±%)						(18,000
3	Transmission line—Dengi Substation to Gafarsa Substation No. 2 near Addis Ababa, 161 KV, double-circuit steel tower with one circuit installed initially, consisting of one overhead ground wire and three 954 MCM ACSR conductors. Average terrain, little clearing. Second circuit to be installed later for Nashe line.	248	kms	50,000.00	12,400,000	(12,400,000)	
	Engineering and General Expense (20±%)						(2,480,000
4	Gafarsa Substation No. 2—Stage 01 near Addis Ababa. 100,000 KVA, 161/132 KV. Bays Y5, Y6, W1, W2, and W3 complete with autotransformer installation KY5A. See Dwg. No. 4.0-BN-174					(2,950,000)	
	Bay Y5	Lump Sum		Lump Sum	300,000		
	Bay Y6	Lump Sum		Lump Sum	300,000		
	Bay W1	Lump Sum		Lump Sum	250,000		
	Bay W2	Lump Sum		Lump Sum	250,000		
	Bay W3	Lump Sum		Lump Sum	250,000		
	KY5A and appurtenances	Lump Sum		Lump Sum	1,600,000		
	Engineering and General Expense (25±%)						(737,500
	MISCELLANEOUS JOINT-USE FEATURES					3,325,000	4,156,000
1	Road from top of escarpment down to Ixr. Diversion Dam. Two lane, steep mountainous.	20	kms	58,000.00	1,160,000		
2	Permanent camp	Lump Sum		Lump Sum	1,500,000		
	Subtotal				2,660,000		
	Contingencies (25±%)				665,000		
	Field Cost—Misc. Joint-use Features				3,325,000		
	Engineering and General Expense (25±%)				831,000		
	Total est. const. cost—Misc. Joint-use feature.				4,156,000		

TABLE V-1

prices as itemized with unit prices in Table V-1. Electrical facilities, such as the powerplant and transmission plant, were derived from curves based on U. S. Bureau of Reclamation practices and design modified to local conditions. Table V-2 summarizes estimated costs for the various features and includes the estimated allocated cost for the joint-use facilities and the cost of contingencies, engineering, and general expense.

Plan Selection and Alternatives

On the basis of preliminary studies, the plan as selected appeared to be the most feasible economically. The natural falls favored production of hydroelectric power, and the water releases were oriented in this direction rather than toward irrigating more land. The plan as finally selected represents an optimum balance between irrigation and power development.

Alternative damsites were investigated for storage and power diversion. One plan briefly studied included using only one dam for both storage and power diversion, located approximately midway between the falls and the outlet of the swamp. Rough estimates indicated that the combination of the higher dam to store the equivalent amount of water, due to the river slope and the additional length of tunnel for power development, would be more expensive than the two low dams selected.

Visual geological examination of the site precluded the employment of a vertical shaft tunnel and an underground powerplant, which would have been the most economical and desirable solution. Drilling will be required for final determination of plan to evaluate the rock formation. The location of both the tunnel and the penstocks in the selected plan appears to be the more economical alternative.

A higher location of the canals in the project land area was considered, but it was found that locating the canals to serve all of the land classified would mean high construction cost and excessive maintenance problems, since such location would place the canals near the escarpment on steep talus slopes. Some small amount of pumping could be done to reach areas above the gravity canal, but these would be only small scattered areas and were not considered in this study.

TABLE V-2 - ESTIMATED CONSTRUCTION COST SUMMARY
FINCHAA PROJECT

Feature	In thousands of Ethiopian dollars				
	Total construction cost	Joint-use		Total irrigation features	Total power features
		Power	Irrigation		
Finchaa Dam and Reservoir	682	371	311	311	371
Power Diversion Dam	210	---	---	---	210
Power Tunnel and Penstocks	32,948	---	---	---	32,948
Powerplant	11,015	---	---	---	11,015
Transmission Plant	21,004	---	---	---	21,004
Irrigation Diversion Dam	545	---	---	545	---
East Main Canal	3,031	---	---	3,031	---
West Main Canal	1,989	---	---	1,989	---
Distribution System	7,734	---	---	7,734	---
Drains	2,813	---	---	2,813	---
Access Roads	1,813	986	827	827	986
Permanent Camp Facilities	2,343	1,275	1,068	1,068	1,275
Subtotal	86,127	2,632	2,206	18,318	67,809
Development Cost 1/	5,325	---	---	5,325	---
Total Construction Cost	91,452	2,632	2,206	23,643	67,809

1/See SECTION VIII for details.

AMARTI-NESHE PROJECT

Plan of Development

The development plan for the multipurpose Amarti-Neshe Project includes two storage dams, a power canal and tunnel, penstocks, powerplant, transmission facilities, irrigation diversion dam, two main canals, a distribution system, and drainage canals to provide irrigation for 8,490 hectares of land and 80,000 kilowatts of power installation.

Storage requirements for the project are to be provided by utilizing the Amarti and Neshe River Basins, connected by an open-ditch channel through a narrow saddle that separates the two basins. The Amarti River channel is almost 42 meters higher in elevation than that of the Neshe and water would be impounded by a low masonry dam that will also serve as a spillway for both reservoirs.

Discharges would be made from the outlet works in the Neshe Dam into a power canal, then to a tunnel and penstocks for production of hydroelectric power. The powerplant would discharge into the Neshe River channel and irrigation water would be diverted by a diversion dam into two main canals for conveyance to the distribution system and farmers' headgates.

The features of the multipurpose project plan are shown in plan on Drawing No. 2.0-Fi-6 and are described in reconnaissance detail in the following paragraphs. Topography of the area was developed in the same manner as on the Finchaa Project area.

Project Features

Amarti-Neshe Dams and Reservoirs

Neshe Dam. The Neshe Dam would be located about 1.3 kilometers upstream from the lip of the falls on the Neshe River. It would be an earth-rockfill dam having a structural height of 60 meters and a crest length of 1,100 meters. Diversion during construction would be accomplished through a gap in the dam, the gap to be closed during the dry season following the completion of the outlet conduit. See Drawing No. OA-23-91 for plan, section, and profile of the Neshe and Amarti Dams.

Neshe Dam Data

Type	earth-rockfill
Earth embankment, volume	2,300,000 cu. m.
Rock embankment, volume	3,100,000 cu. m.
Elevation of crest	2243 m.
Freeboard	2.41 m.
Structural height	60 m.
Hydraulic height	57.59 m.
Length of crest	1,100 m.
Width of crest	10 m.

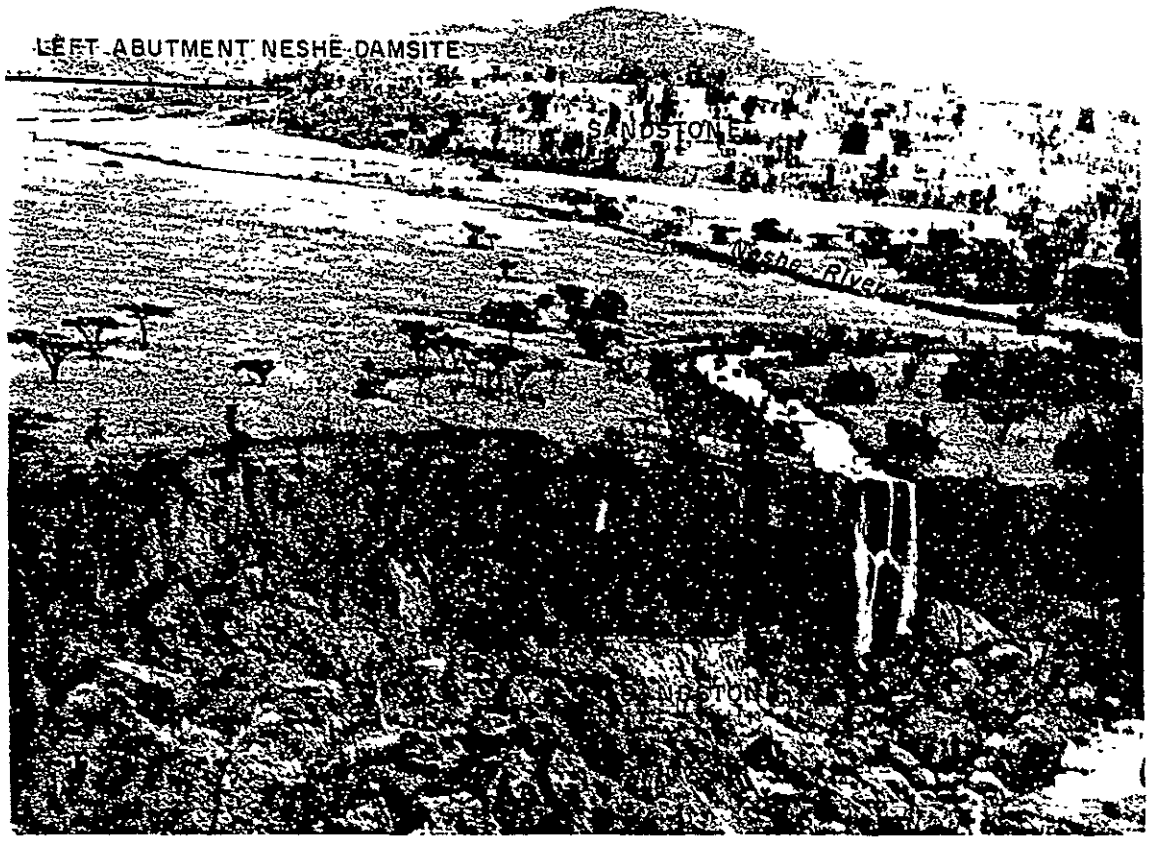
Amarti Dam Spillway. By construction of an equalizing channel, the two reservoirs in effect will become one and for hydraulic purposes will be treated as one. The Amarti Dam is planned to serve as a spillway for passing the flood flows for the combined reservoir. Located about five kilometers south of the Neshe Dam and on the Amarti River upstream from the falls, the dam would have a concrete-masonry overflow section abutting a complacted earthfill dike. The spillway section would be 250 meters long with the total earth dike section on both ends of the spillway being 335 meters long. In routing the flood, it was assumed that the reservoir would be full to normal water surface elevation of 2236 meters. With the design inflow flood indicating a peak discharge of 1,939 cubic meters per second and a 2.5-day volume of 116 million cubic meters, the spillway at maximum water surface elevation of 2237.59 meters will discharge 962 cubic meters per second over the ogee concrete crest.

Amarti Dam Spillway Data

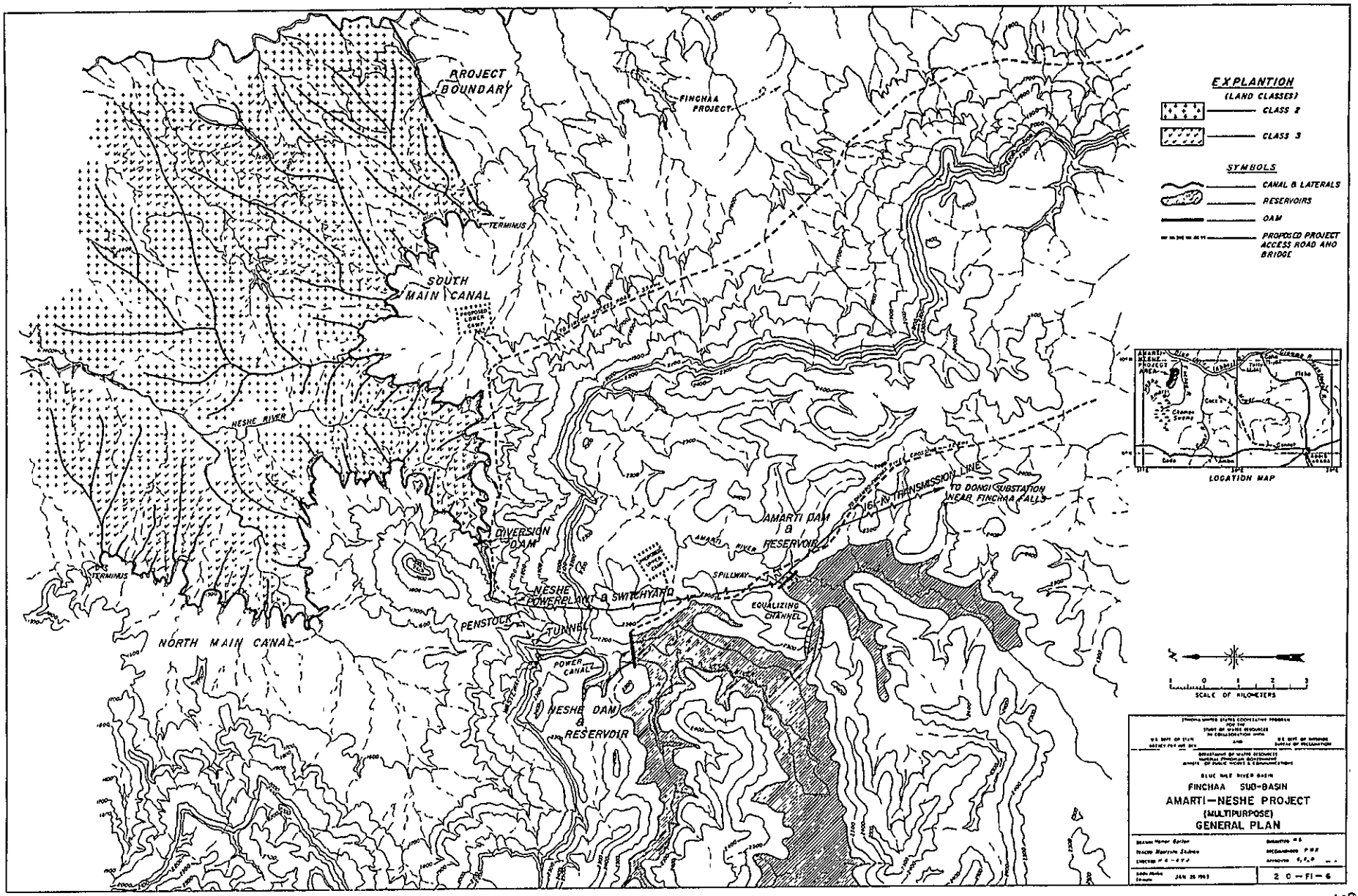
Type	concrete-masonry and earth embankment
Top of dam	2240 m.
Spillway crest elevation	2236 m.
Inflow design flood	1,939 cu. m. per sec.
Volume of concrete and masonry in embankment	53,000 cu. m.
Volume of earth in embankment	170,000 cu. m.
Structural height	15 m.
Hydraulic height	12.59 m.
Length of spillway crest	250 m.
Discharge at maximum w.s. elevation	962 cu. m. per sec.

Neshe Dam Outlet Works. The outlet works would be located on the left abutment of the Neshe Dam. It would consist of an intake structure; a 3.05-meter, horseshoe, concrete conduit under pressure to the gate chamber where a 1.53- by 1.53-meter slide gate is provided for emergency control; and a 1.73-diameter steel outlet pipe from the gate chamber to release water through two metal slide gates discharging into a stilling basin.

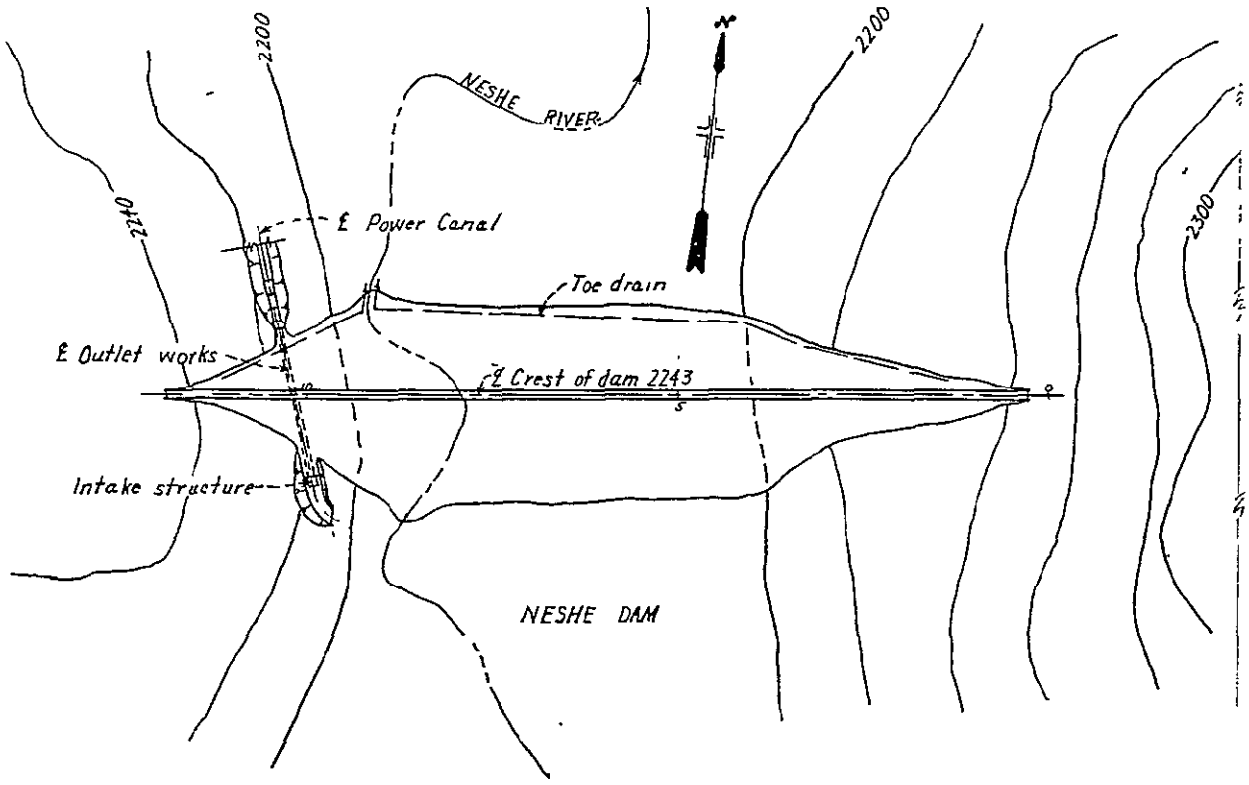
9



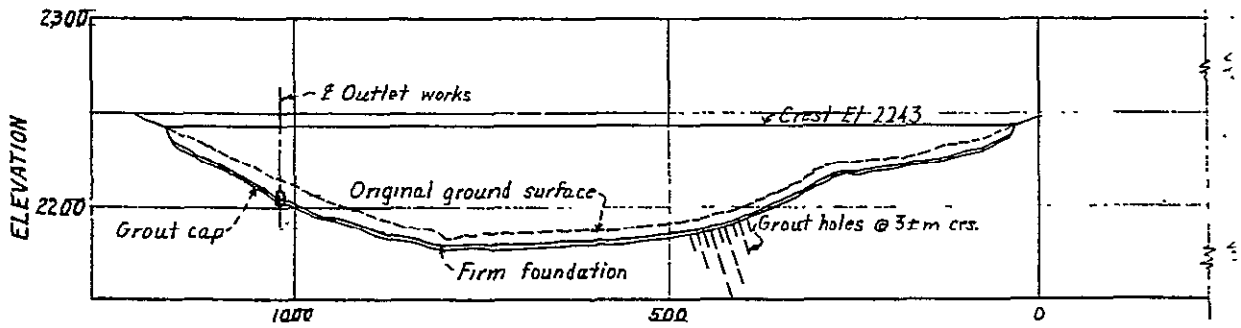
NESHE DAMSITE NE-1 & INTERVALLEY BASALT- LOOKING UPSTREAM


PROJECT BOUNDARY
FINCHAA PROJECT
TERMINUS
SOUTH MAIN CANAL
PROPOSED LOWER CAMP
NESHE RIVER
TERMINUS
NORTH MAIN CANAL
DIVERSION DAM
NESHE POWERPLANT & SWITCHYARD
PENSTOCK
TUNNEL
POWER CANAL
NESHE DAM & RESERVOIR
AMARTI DAM & RESERVOIR
AMARTI RIVER
SPILLWAY
EQUALIZING CHANNEL
161-KV TRANSMISSION LINE
TO DONGI SUBSTATION NEAR FINCHAA FALLS
EXPLANTION
(LAND CLASSES)
CLASS 2
CLASS 3
SYMBOLS
CANAL & LATERALS
RESERVOIRS
DAM
PROPOSED PROJECT ACCESS ROAD AND BRIDGE
LOCATION MAP
SCALE OF KILOMETERS
BLUE NILE RIVER BASIN
FINCHAA SUB-BASIN
AMARTI—NESHE PROJECT
(MULTIPURPOSE)
GENERAL PLAN
JAN 26 1963
2 C — FI — 6

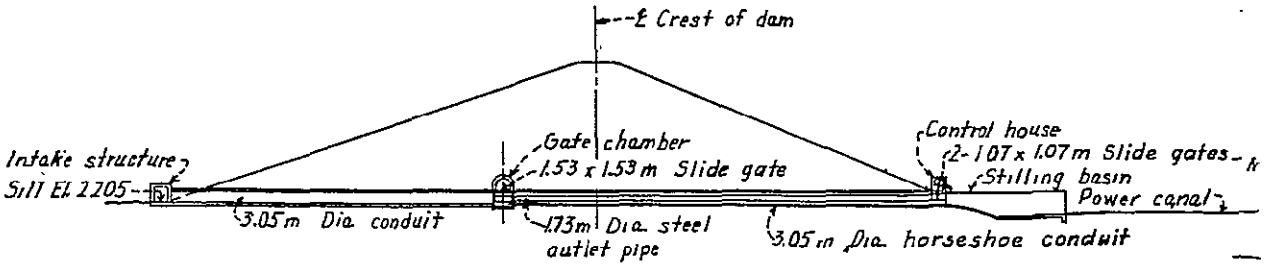
100



GENER
SCALE

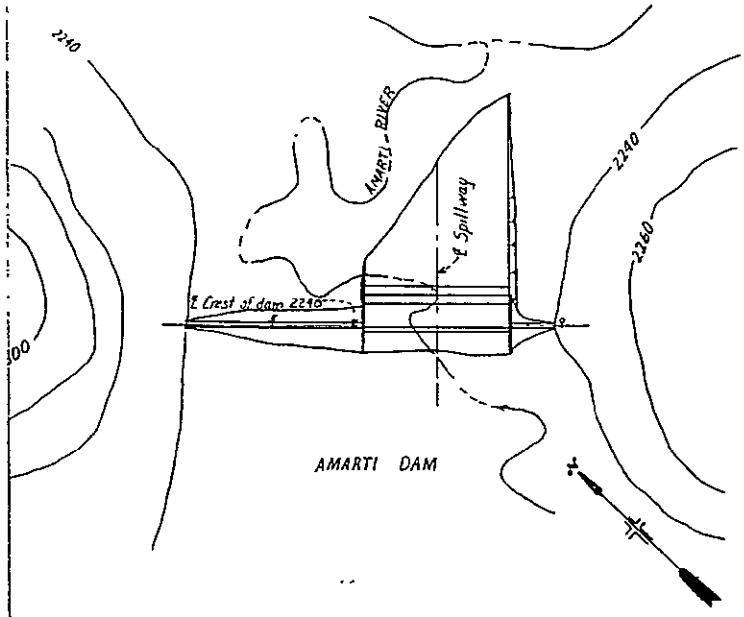


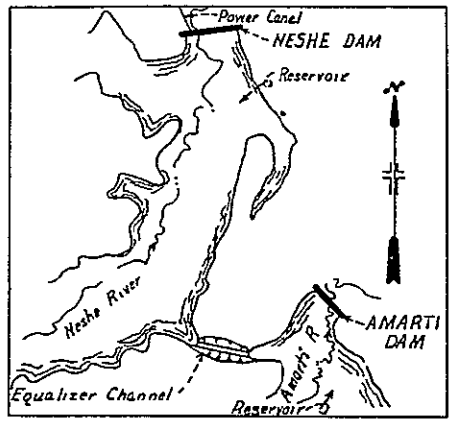
PROFILE ON ℄ CREST OF D



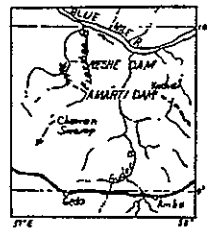
NESHE DAM OUTLET WORKS

Orig

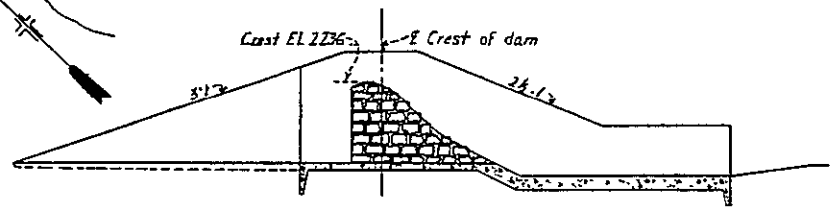




VICINITY MAP

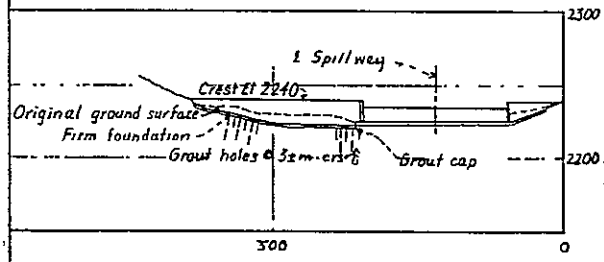


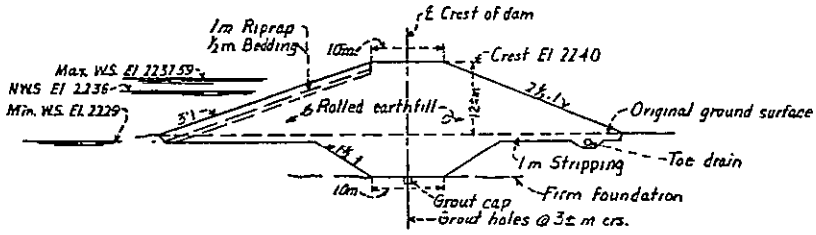
LOCATION MAP



AMARTI SPILLWAY

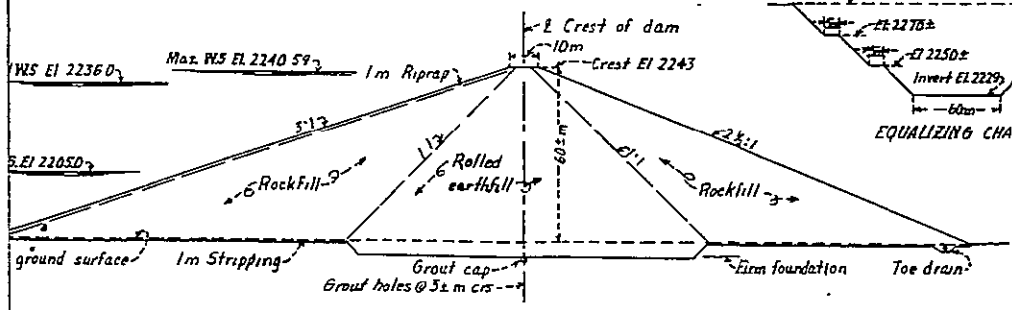
PLAN





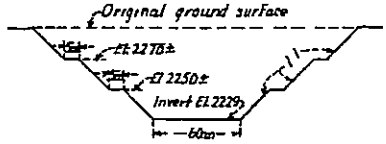
AMARTI DAM TYPICAL SECTION

SCALE OF METERS



NESHE DAM MAXIMUM SECTION

SCALE OF METERS



EQUALIZING CHANNEL

ETHIOPIA–UNITED STATES COOPERATIVE PROGRAM
FOR THE
STUDY OF WATER RESOURCES
IN COLLABORATION WITH
U.S. DEPT OF STATE AGENCY FOR INT DEV AND U.S. DEPT OF INTERIOR BUREAU OF RECLAMATION

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

NESHE DAM (NES-1)
AMARTI DAM (AM-1)

DENVER, COLORADO NOVEMBER 15, 1965

OA-23-91

Outlet Works Data

Sill elevation	2205 m.
Capacity at w.s. elev. 2214.89	20 cu. m. per sec.
Type of gate	slide gates

Reservoirs. Both the Amarti and the Neshe Basins are covered with clay, forming an excellent impermeable blanket. Seepage is not considered a serious problem. The wide, flat-bottomed, grassland valleys are underlain by a thin flow of younger basaltic lava which has prevented rapid downward erosion. The reservoir at normal water surface elevation would impound 847 million cubic meters of water covering an area of 53 square kilometers. Reservoir data are shown on Drawings Nos. 2.2-BN-3 and -4; the area-capacity curve is shown on Drawing No. 2.0-Fi-14, including sediment disposition.

Site Geology

Amarti-Neshe Damsites. The upstream drainage area and source of the water supply for the Amarti-Neshe projects originates on the high plateau of Adigrat sandstone capped by volcanic rock. On the lower portion of the plateau only isolated remnants of the volcanic materials remain. Younger volcanic rock occupies the lower portion of previously eroded stream channels and, being harder than the sandstone, maintains vertical waterfalls at the brink of the plateau, thus retarding downward erosion on the plateau. The plateau streams meander through gently sloping grassland meadows with poorly defined stream channels. Exposures of basalt at the waterfalls range from three to ten meters thick, but it is anticipated that at the proposed dam axis upstream the basalt cover may be much thinner. Due to the soil cover and the heavy growth of swamp grass, the intervalley flow of basalt is not exposed. The ridges forming the abutments for the proposed dams are composed of sandstone.

The plateau breaks sharply several hundred meters below to gently sloping project lands that could be supplied with water for irrigation after its passage through the hydroelectric powerplant. Reservoir storage would be provided on the plateau by constructing dams on both the Amarti and the Neshe Rivers. The reservoirs would be operated as a single unit by excavating an interconnecting channel between the two reservoirs; thus, only one spillway would be required, probably at the Amarti Dam. The interconnecting channel is in sandstone, and no doubt most of the excavated material can be used as borrow material for constructing the Neshe earthfill dam. The Amarti Dam would probably be a concrete or masonry structure in order to provide a weir type spillway over the dam.

The power canal would be in sandstone, as would the tunnel and penstock leading to the Neshe powerplant located at the base of the plateau. The foundation material for the Neshe powerplant is sandstone. No difficult foundation problems are anticipated.

The small diversion dam to be located downstream from the Neshe powerplant would be founded on sandstone. From this diversion dam, a North Main Canal and a South Main Canal would transport water to project lands located on both sides of the river. Most of the project land is of deep alluvial and slopewash soil underlain by sandstone, except that there is metamorphic rock in the lower portion of the project area.

The damsites on the Neshe and Amarti Rivers are very similar, and geologic conditions are essentially identical. The wide, flat bottomed, grassland valleys are underlain by a thin flow of "younger" basaltic lava which has prevented rapid downward erosion. The stream meanders over the grassy meadow in a shallow, hardly recognizable, stream channel on a clayey soil blanket. Only at the falls at the brink of the plateau is the basalt exposed. At the falls, the basalt is up to ten meters thick. The clay blanket is estimated to be from two to five meters thick at the damsites. Beneath the clay blanket the abutments are Adigrat sandstone.

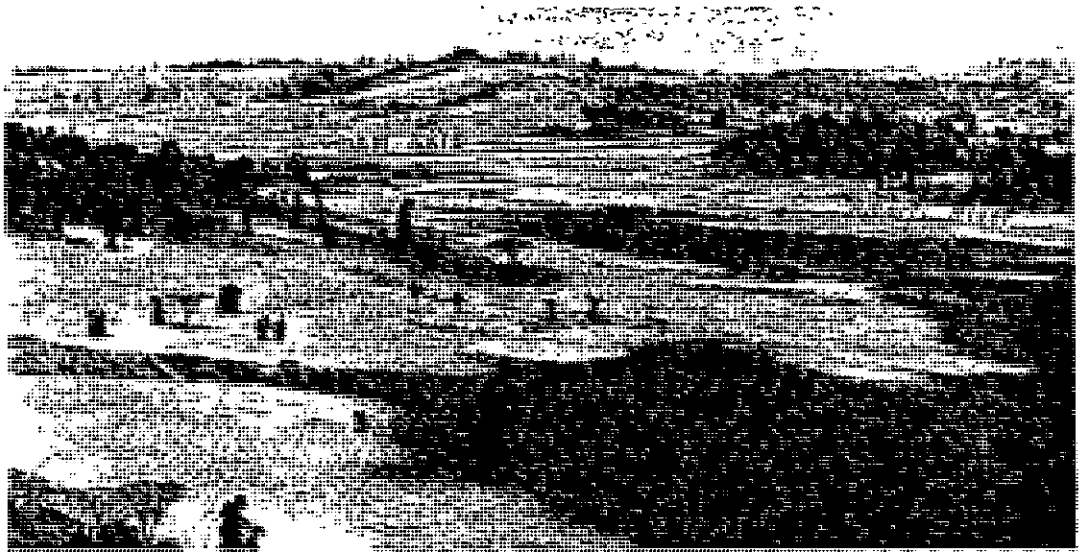
A core drill exploration program would be required to determine excavation depths to the volcanic rock in order to obtain a satisfactory foundation for a concrete or masonry dam. The need for a grout curtain should be anticipated. However, the clay blanket should alleviate excessive leakage from the reservoir.

The cutoff trench for the earthfill dam should extend into the volcanic rock, and a grout curtain is needed along the cutoff trench to assure against leakage.

For reconnaissance designs, cutoff excavations are estimated at an average depth of five meters for both the stream channel section and the abutments.

Construction Materials

Impervious construction materials are available on the slopes and ridges near the damsites and from the interconnecting channel excavations. Riprap and rockfill can be obtained from the intervalley basaltic lava upstream or downstream from the damsites. Volcanic material can also be crushed for concrete aggregate.



AMARTI DAMSITE AM-I - LOOKING DOWNSTREAM

MESHE (w/o Amarti) DAM & RESERVOIR

AREA CAPACITY DATA
(with sediment distributed)

CONTROL POINTS: ITEM & ALLOCATION OF STORAGE CAPACITY		DIAGRAM OF DAM	ELEVATION (METERS)	INITIAL AREA (SQ. METERS – 10^6)	CAPACITY (CUBIC METERS – 10^6): INITIAL INCREMENT	INITIAL TOTAL	WITH 50-YR. SEDIMENT INCREMENT	WITH 50-YR. SEDIMENT TOTAL
TOP OF DAM			2243.00					
MAXIMUM W.S.	FREEBOARD		2240.59	32.7		878.9		868.4
NORMAL W.S.	FLOOD SURCHARGE		2236.00	30.6	143.8	735.1	143.8	724.6
MINIMUM OPERATING W.S.	ACTIVE CAPACITY		2214.89	17.0	507.0	228.1	502.9	221.7
LIP OF LOWEST OUTLET*	INACTIVE CAPACITY		2205.00	9.8	133.1	95.0	131.1	90.6
STREAM BED	DEAD STORAGE AND SILT		2183.00	0	95.0	0	90.6	0

*100-YEAR SEDIMENT OF 21 x 10^6 M^3 WILL TAKE 2184.3 METERS ELEVATION AT THE DAM.

AMARTI DAM & RESERVOIR

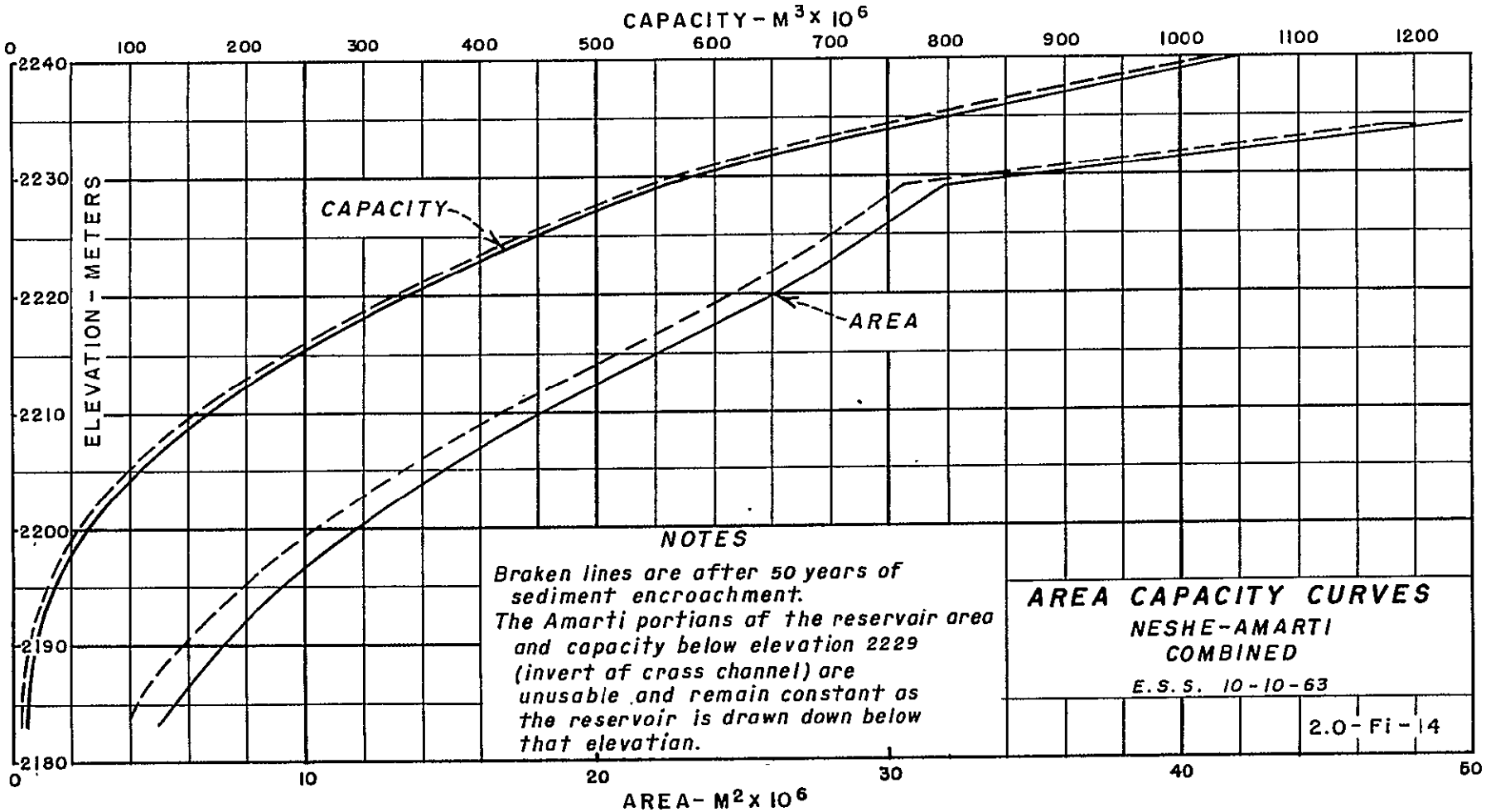
AREA CAPACITY DATA

(with sediment distributed)

CONTROL POINTS: ITEM & ALLOCATION OF STORAGE CAPACITY		DIAGRAM OF DAM	ELEVATION (METERS)	INITIAL AREA (SQ. METERS – 10^6)	CAPACITY (CUBIC METERS – 10^6): INITIAL INCREMENT	INITIAL TOTAL	WITH 50-YR. SEDIMENT INCREMENT	WITH 50-YR. SEDIMENT TOTAL
TOP OF DAM			2240.00					
MAXIMUM W.S.	FREEBOARD		2237.59	25.0		142.9		132.4
NORMAL W.S.	FLOOD SURCHARGE		2236.00	22.8	30.4	112.5	30.4	102.0
	ACTIVE CAPACITY				99.9		93.9	
MINIMUM OPERATING W.S.			2229.00	5.0		12.6		8.1
LIP OF LOWEST OUTLET*	INACTIVE CAPACITY		2229.00	5.0	0	12.6	0	8.1
	DEAD STORAGE AND SILT				12.6		8.1	
STREAM BED			2225.00	0		0		0

*100-YEAR SEDIMENT OF 21 x 10^6 M^3 WILL TAKE 2228.6 METERS ELEVATION AT THE DAM.

2.2-RN-4



NOTES

Broken lines are after 50 years of sediment encroachment.
The Amarti portions of the reservoir area and capacity below elevation 2229 (invert of cross channel) are unusable and remain constant as the reservoir is drawn down below that elevation.

AREA CAPACITY CURVES

NESHE-AMARTI COMBINED

E.S.S. 10-10-63

2.0-Fi-14

The geology is shown on General Geology Reconnaissance Map No. 14, Drawing No. 5.2-Fi-2 (SECTION IV). Geologic sections for the Neshe and Amarti damsites are shown on Drawings Nos. 2.0-Fi-7 and 2.0-Fi-8. The general plan of the Amarti-Neshe Project is shown on Drawing No. 2.0-Fi-6.

Access to Sites

Access to the potential damsites will have to traverse rolling country from the Finchaa River road crossing. This will require construction of an access road for a distance of approximately 12 kilometers with one major river crossing, that of the Amarti River. Access to the powerplant could be made from the proposed Finchaa access road and would require building a road 35 kilometers in length through hilly country. This same road would serve as an access to the project lands.

Power Canal

The power canal conveys the water from the Neshe Dam to the forebay at the tunnel, which in turn supplies the powerplant through penstocks. The canal is about six kilometers long and is designed to supply water to the tunnel at approximately 20 cubic meters per second. Masonry lining for the canal has been provided for. Some forebay storage is necessary, but, due to the fact that the forebay is located close to the edge of the escarpment, the size of the pool may be restricted. With the canal capacity at 20 cubic meters per second, about 5,500 cubic meters of forebay storage to meet daily regulation requirements are indicated. This will require scheduling water releases to the canal from the outlet works to meet anticipated load requirements. Water surface elevations in the canal would be held nearly constant with all but minor fluctuations avoided.

Power Tunnel and Penstocks

The tunnel would be pressure type to withstand the high head. At the beginning, it would be reinforced-concrete lined, but it would require an encased steel pipe at the lower end. It would be about 433 meters long with a diameter of 2.40 meters.

Two welded steel penstocks would be required at the outlet end of the tunnel with butterfly valves for emergency controls. The penstocks would be 1.52 meters in diameter and 1,467 meters long. The thickness would vary from 27 millimeters at the beginning to about 50 millimeters near the end.

Tunnel Data

Type	pressure
Length	433 m.
Diameter	2.40 m.
Design capacity 1/	18.2 cu. m. per sec.

Penstock Data

Type (2 each)	welded steel
Length (each)	1,467 m.
Diameter (each)	1.52 m.
Design capacity (each) 1/	9.1 cu. m. per sec.

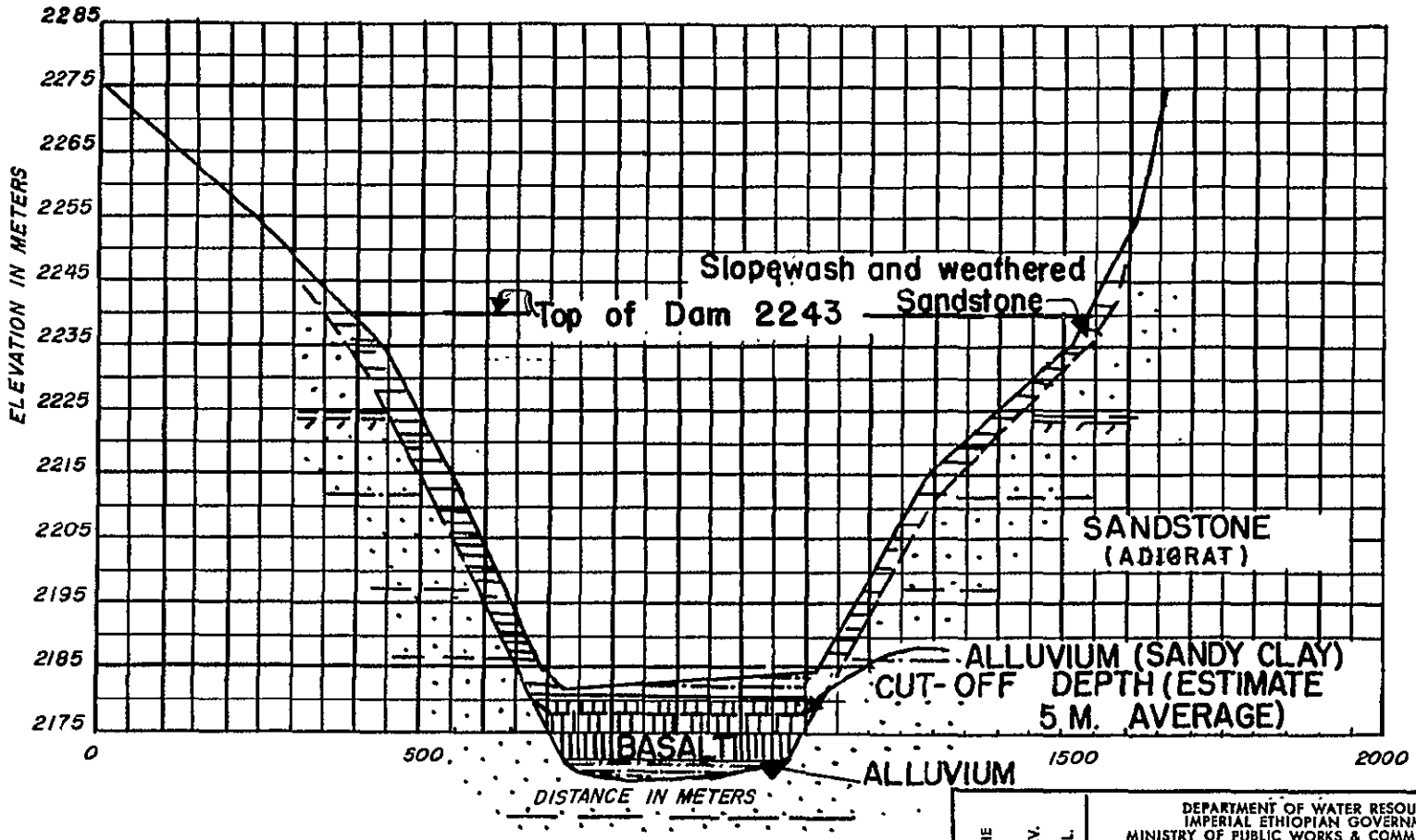
Powerplant

Conveyance of water from the forebay to the powerplant turbines would be by pressure tunnel and welded steel penstock. According to operation studies made (SECTION III), the annual gross generation would be 378,000,000 kilowatt-hours for an adverse water supply period. Two generator units of 40 mw. each would be satisfactory, providing a total plant capacity of 80 mw. or 100 mv.-a. at 0.8 power factor.

Due to the high head, 560 meters (net), the two turbines will be of the impulse-type, each rated 55,725 metric hp. (56,500 English hp.), and could be double-runner with a single jet per runner, all very similar to the Finchaa powerplant installation. Horizontal shaft, double-overhung, single-nozzle, 375-r.p.m. wheels would be adequate. The flow of water to the turbines would be controlled by a needle valve from governor action related to load demand, and the governor would also simultaneously operate a pressure regulator to by-pass water from the penstock, during load surges, to the tailrace. Energy absorbers are required to dissipate water from the pressure regulators.

The two generators would have individual step-up transformers, as shown by Drawing No. 4.0-BN-87, from 13.8-kv. generator voltage to 161-kv. transmission voltage, each transformer rated 50,000 kv.-a. Certain powerplant components have been made identical with the Finchaa powerplant so as to ease the operation and maintenance problems and to reduce the investment in spare parts. The switchyard arrangement is identical to that shown for the Finchaa powerplant.

1/Peaking capacity has been included in these facilities. They are adequate to supply water to the powerplant, permitting the generators to meet expected normal load requirements initially, with future use for possible peaking operation.



DIAGRAMMATIC GEOLOGIC SECTION

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF STAGEN. FOR INT DEV. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

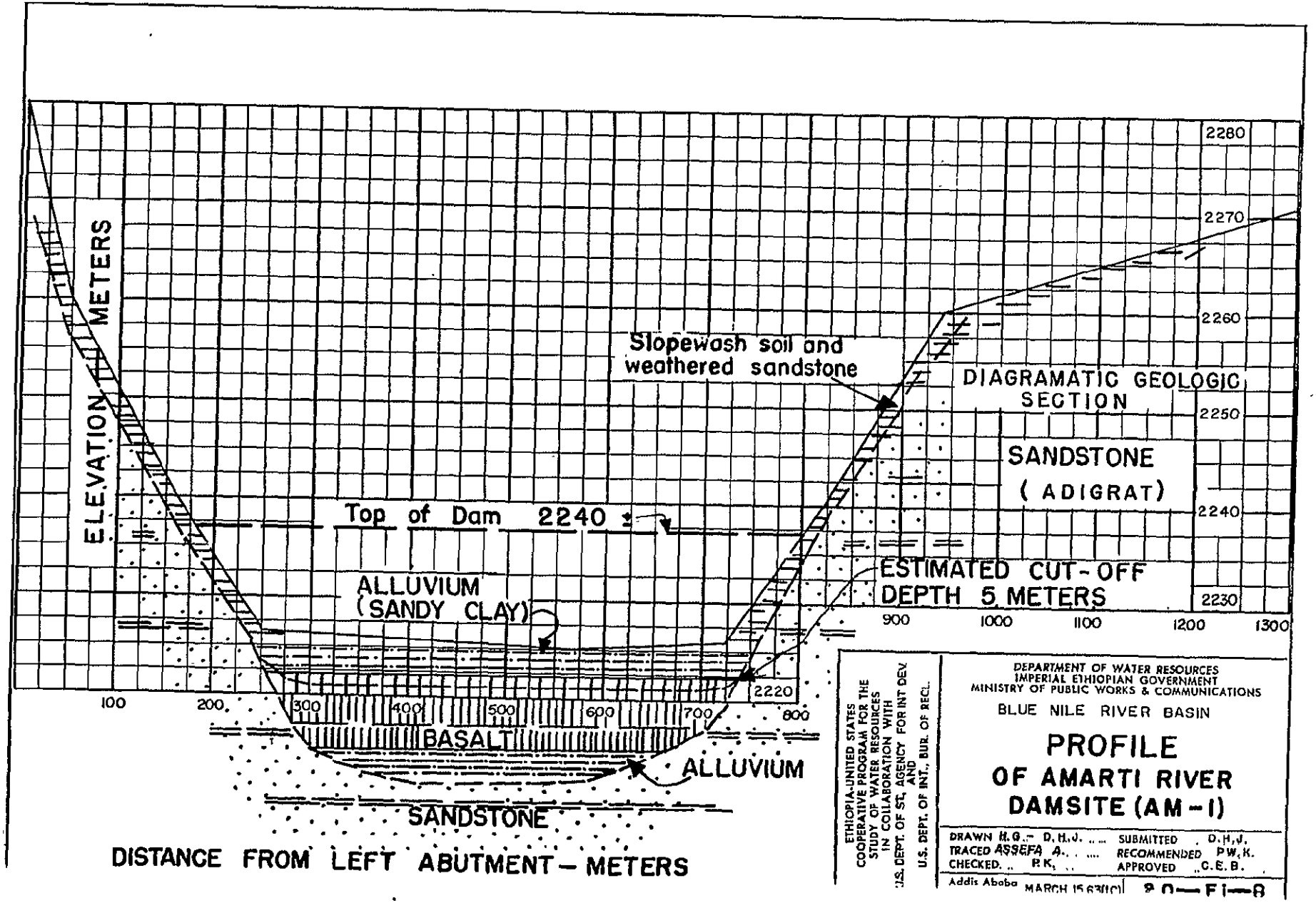
BLUE NILE RIVER BASIN

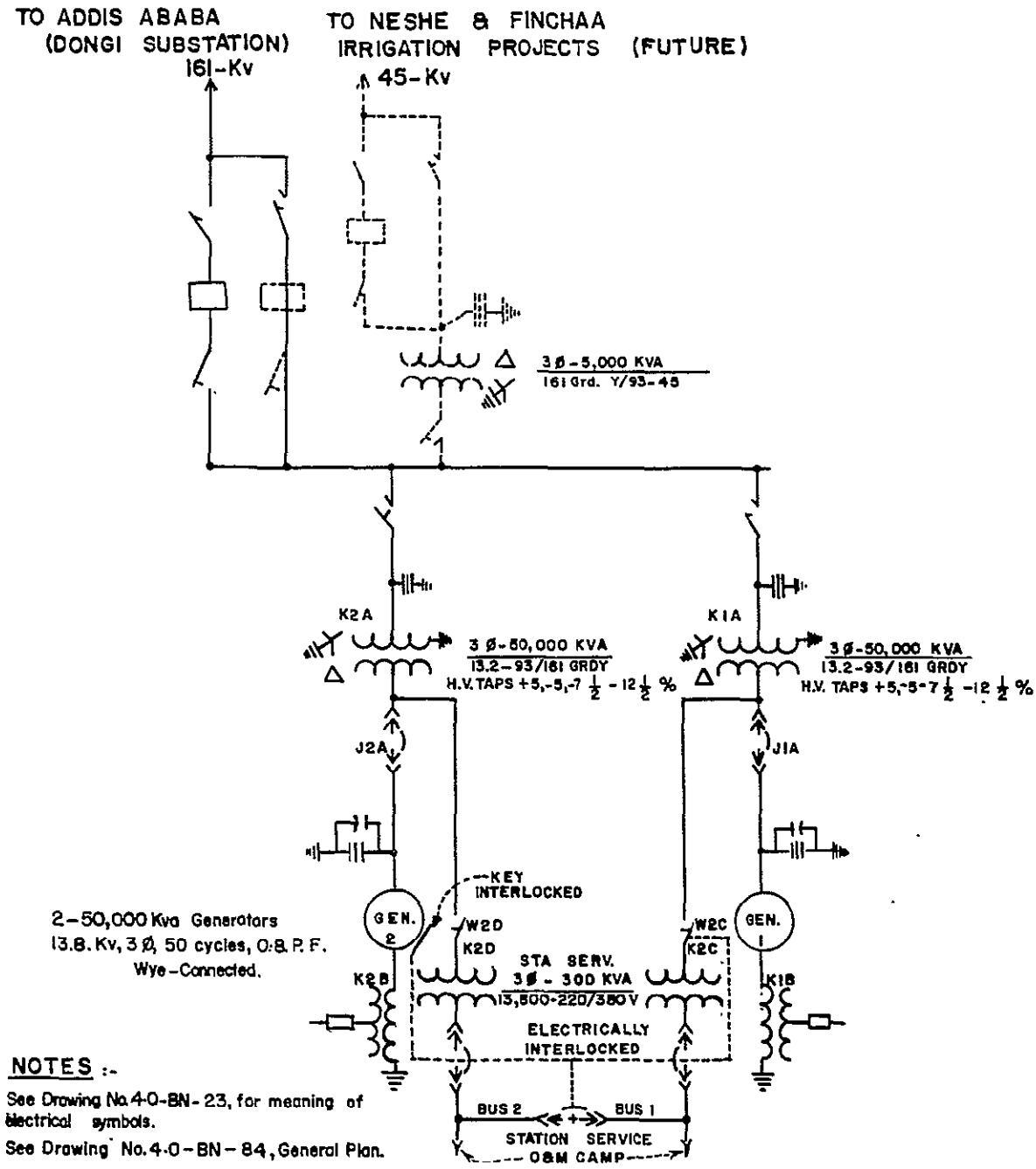
PROFILE

NESHE RIVER DAM SITE (NES-1)

DRAWN H.G. G.G. SUBMITTED D.H.J.
TRACED Gebrehiwot Zewdie RECOMMENDED P.W.K.
CHECKED G.L.C. D.H.J. APPROVED C.E.B.

Addis Ababa Ethiopia March 14, 1963 | 20-Fi-7


ELEVATION METERS
2280
2270
2260
2250
2240
2230
Slopewash soil and weathered sandstone
DIAGRAMATIC GEOLOGIC SECTION
SANDSTONE (ADIGRAT)
Top of Dam 2240 ±
ESTIMATED CUT-OFF DEPTH 5 METERS
ALLUVIUM (SANDY CLAY)
900
1000
1100
1200
1300
2220
100
200
300
400
500
600
700
800
BASALT
ALLUVIUM
SANDSTONE
DISTANCE FROM LEFT ABUTMENT – METERS
ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST. AGENCY FOR INT DEV. AND U.S. DEPT. OF INT., BUR. OF RECL.
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN
PROFILE
OF AMARTI RIVER
DAMSITE (AM-1)
DRAWN H.G.- D.H.J.
TRACED ASSEFA A.
CHECKED. R.K.
SUBMITTED D.H.J.
RECOMMENDED P.W.K.
APPROVED C.E.B.
Addis Ababa MARCH 15 63(10)
P O — F I — 8



2-50,000 Kva Generators
13.8. Kv, 3 Ø, 50 cycles, 0.8. P. F.
Wye-Connected.

NOTES :-

1. See Drawing No. 4-0-BN-23, for meaning of electrical symbols.
2. See Drawing No. 4-0-BN-84, General Plan.
3. For location Dongi Substation, See Drawing No. 4-0-Fi-13.
4. Elevation 1625 meters.

ETHIOPIA-UNITED STATES
COOPERATIVE PROGRAM FOR THE
STUDY OF WATER RESOURCES
IN COLLABORATION WITH
U.S. DEPT. OF ST., AGEN. FOR INT. DEV.
AND
U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN

SWITCHING DIAGRAM
NESHE RIVER POWERPLANT
NESHE RIVER FALLS

DRAWN C.L.C. SUBMITTED C.L.C.
TRACED Gebre Christos RECOMMENDED P.W.K.
CHECKED C.L.C. G.V.J. APPROVED C.E.B.

Addis Ababa Ethiopia Jan. 1963. 4-0-BN-87

11

Summarizing, the generators would have the general characteristics shown below.

Speed	375 r.p.m.
Number of poles	16
Horizontal shaft, direct connected	
Voltage, wye connected	13.8 kv.
Frequency	50 cycles
Power factor, variable, 0.8 thru unity, lag or lead	

Transmission Plant

Transmission Lines. See the discussion for the Finchaa powerplant. A single-circuit, steel tower, 954-MCM ACSR conductor, transmission line will be required from Neshe powerplant to the site of the Dongi Substation on the escarpment very near the Finchaa power diversion dam above the Finchaa powerplant (Dwgs. Nos. 2.0-Fi-2 and -6), a distance of about 32 kilometers. From the Dongi Substation to Addis Ababa it will be necessary to install only the three, 954-MCM ASCR conductors on one side of the existing double-circuit steel tower line.

Substations. The Dongi Substation (see Dwg. No. 2.0-Fi-2) will initially be a switching station so as to provide for some flexibility in operation and maintenance. However, it will not be required until the Neshe power facilities are constructed, and at that time the single-circuit 161-kv. line (32 km.) from Neshe and the 161-kv. single-circuit line (1.8 km.) from Finchaa will terminate at the Dongi Substation. Also terminating at the Dongi Substation will be the 248-km., 161-kv., double-circuit line to Addis Ababa, as previously discussed. Prior to the construction of Neshe there will be about 249.8 km. of 161-kv. line, consisting of 1.8 km. of single-circuit tower construction and 248 km. of double-circuit tower construction carrying one circuit, in operation.

Stage 02 in the receiving-end substation at Addis Ababa to provide proper terminal facilities for the second 161-kv transmission circuit from Neshe will be needed. See discussions on substations, Finchaa Project. Stage 02 in Gafarsa Substation No. 2 is shown on Drawing No. 4.0-BN-174 and will consist of a line bay and a transfer bay in the 161-kv. yard as well as a second 161/132-kv. autotransformer bank, KY3A, to parallel the first autotransformer bank, KY5A. In addition, another 132-kv. line bay position and a 132-kv. transfer bay are necessary, all as explained by Note 2 on Drawing No. 4.0-BN-174.

The reactive control facilities, consisting essentially of two synchronous condensers, may not be required at the time the Neshe facilities are placed into operation, all depending upon the reactive support obtained from the Awash plants. However, with both plants delivering full output on peak to the Addis Ababa area, and receiving no reactive support at the receiving-end terminal, the synchronous condenser installation will be required. For light load conditions, either shunt reactors or synchronous condensers operated lagging may be needed. Synchronous condenser installations made early enough could provide for the light load requirements initially and also provide for the heavy load reactive support later. During the feasibility stage of investigations more data will be available regarding the Awash machine characteristics and load characteristics, including the reactive problem at principal load centers. For this study, the added cost of the synchronous condensers will be included, recognizing that an installation of the size shown may or may not be required, depending upon the factors noted above.

Irrigation Diversion Dam

The dam would be located a short distance upstream from the confluence of the Amarti and Neshe Rivers. It would divert the flows from the discharges of the powerplant into the two main canals for irrigation purposes. Because the flood flows are passed through the Amarti Dam spillway and thence into the Amarti River, the possible flood flows at the diversion dam were found to be negligible. The diversion dam is envisioned as an overflow, masonry-concrete dam with suitable outlet and sluice works provided.

Irrigation Diversion Dam Data

Volume of masonry	1,850 cu. m.
Normal water surface elevation	1,501.5 m.
Structural height	5.0 m.
Crest length of spillway	60.0 m.
Length of dam	83.0 m.

Main Canals

Since they are part of the larger Finchaa valley, the descriptive narrative included in the Finchaa Project would apply. Two main canals are also planned for this project to convey the water to the land.

South Main Canal. The South Main Canal would extend in an easterly direction for about 39 kilometers. It would originate at the discharge end of the outlet works on the right abutment of the diversion dam. The canal would be open and unlined, with an initial

capacity of 11.65 cubic meters per second. It would traverse innumerable draws and ravines, requiring suitable structures to accommodate the high flows of the rainy reason. Canal excavation will not present any major problems, but rock will probably be encountered in a few isolated reaches. The canal is designed to serve by gravity 6,360 hectares of irrigable lands.

South Main Canal Data

Length	39 km.
Type	unlined
Initial capacity	11.65 cu. m. per sec.
Initial w.s. elevation	1500 m.

North Main Canal. The North Main Canal would extend in a northerly direction for about 29.4 kilometers. It would originate at the discharge end of the outlet works on the left abutment of the diversion dam. The canal would have an initial capacity of 3.5 cubic meters per second designed to serve approximately 2,130 hectares of land.

North Main Canal Data

Length	29.4 km.
Type	unlined
Initial capacity	3.5 cu. m. per sec.
Initial w.s. elevation	1500 m.

Distribution System and Drains

The distribution system and surface drainage requirements are similar to those of the Finchaa Project, and costs of these items have been estimated at Eth$330 and Eth$120 per hectare, respectively, excluding contingencies, engineering, and general expense.

Service Facilities

Service facilities will be required for construction and later for operation and maintenance of the project features. Cost for this item has been estimated on the same basis as for Finchaa Project.

Estimates of Construction Cost

The construction cost for the multipurpose Amarti-Neshe Project is estimated at Eth$123,020,000 on the basis of January 1961 prices as itemized with unit prices on Table V-3. Electrical facilities,

such as the powerplant and transmission plant, were derived from curves based on U. S. Bureau of Reclamation practices and design modified to local conditions. Table V-4 summarizes estimates for the various features and includes the estimated allocated cost for the joint-use facilities and the cost for contingencies, engineering, and general expense.

Plan Selection and Alternatives

The plan of development proposed, as in the case of the Finchaa Project, was to utilize to its maximum the power head available, with irrigation as a secondary objective, inasmuch as hydrologic studies indicated that there was an abundance of water for irrigation.

Alternative plans studied included a plan to divert the Amarti River into the Chomen Swamp. However, the cost of the larger cut to divert the stream and the fact that the Neshe River could not be utilized, since the stream is 35 meters lower than the Amarti, made the plan unattractive.

A plan was considered to produce power from the Amarti Dam and Reservoir rather than from the Neshe, due to the slightly higher head available. However, because of the difference in elevation of the two reservoirs, it was found that much of the Neshe storage would be inactive.

Operation studies indicate that the two reservoirs will produce approximately twice the amount of water required for irrigation for the 8,490 hectares of land. Further land classification studies will be needed to determine if additional land can be made available.

Similar geological conditions as those applying to the Finchaa Project precluded the employment of an underground powerplant. The plan selected under these circumstances appeared to be the most economical and feasible.

Project AMARTI-NESHE--Multiple-purpose

Date of Estimate November 1963 — Currency in terms of Ethiopian Dollars

Prices as of January 1961 — (U.S $ 1.00 = Eth $ 2.50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	POWER CANAL --Capacity, 20 m^3/sec; length 6,000 meters from stilling basin Dam to tunnel inlet, including fore-bay storage. Lined					1,770,300	2,213,000
1	Canal excavation, common	105,410	m^3	0.82	86,436		
2	Canal excavation, rock	26,400	m^3	8.00	211,200		
3	Parallel drain excavation, common	3,000	m^3	0.82	2,460		
4	Grouted rubble paved waterway	66,252	m^2	15.00	993,780		
	Terminal Structure						
5	Excavation for structure, common	720	m^3	4.00	2,880		
6	Excavation for structure, rock	180	m^3	8.00	1,440		
7	Excavation for wasteway channel, some rock	1,800	m^3	3.50	6,300		
8	Concrete, structural	104	m^3	210.00	21,840		
9	Concrete, in slabs	49	m^3	150.00	7,350		
10	Grouted rubble paved waterway	140	m^2	15.00	2,100		
11	Reinforcement steel	6,900	kgs	1.00	6,900		
12	Radial gates and hoists						
	4 - 2.00 x 2.00 meter	4,000	kgs	5.50	22,000		
	2 - 2.00 x 6.40 meter	7,300	kgs	5.50	40,150		
13	Trashrack and misc. metal work	3,200	kgs	2.60	8,320		
14	Fence, 2 meter chainlink with 3 m gate	80	lm	39.20	3,136		
	Subtotal				1,416,292		
	Contingencies (25±%)				354,008		
	Field Cost -- Power Canal				1,770,300		
	Engineering and General Expense (25-%)				442,700		
	Total est. construction cost--Power Canal				2,213,000		
	POWER TUNNEL -- Concrete lined pressure tunnel, 433 meters long; diameter, 2.40 meters; max. head, 200 meters					1,957,300	2,251,000
1	Excavation, tunnel	2,685	m^3	158.00	424,230		
2	Concrete in tunnel lining	730	m^3	238.00	173,740		
3	Tunnel supports and lagging	Lump sum		L.S	98,500		
4	Reinforcement steel	120,300	kgs	1.12	134,736		
5	Incased steel pipe	196,550	kgs	3.43	674,167		
6	Grouting and drainage	Lump sum		L.S.	60,500		
	Subtotal				1,565,873		
	Contingencies (25±%)				391,427		
	Field cost -- Power Tunnel				1,957,300		
	Engineering and General Expense (15-±%)				293,700		
	Total est. const. cost -- Power Tunnel				2,251,000		
	IRRIGATION CANALS -- Unlined					2,378,200	2,973,000
	South Main Canal and laterals over 1.0 m^3/sec -- length, 39.0 kms; capacity, 11.65 to 2.24 m^3/sec.					(1,595,300)	(1,994,000)
1	Canal excavation, common	319,300	m^3	0.82	261,826		
2	Canal excavation, rock	35,500	m^3	8.00	284,000		
3	Compacting embankment	91,620	m^3	0.98	89,788		
4	Structures	Lump sum		L.S.	539,000		
5	Gates, hoists, values and misc. metalwork	Lump sum		L.S.	12,700		
6	Concrete pipe	Lump sum		L.S.	25,400		
7	Other miscellaneous work	Lump sum		L.S.	63,500		
	Subtotal				1,276,214		
	Contingencies (25±%)				319,086		
	Field Cost -- South Main Canal				1,595,300		
	Engineering and General Expense (25-%)				398,700		
	Total est. const. cost -- South Main Canal				1,994,000		

TABLE V-3

Project AMARTI-NESHE--Multiple-purpose

Date of Estimate November 1963

Currency in terms of Ethiopian Dollars

Prices as of January 1961

(U.S. $ 1.00 = Eth $ 2.50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	AMARTI Dam--Earthfill; max. height, 12 meters;						
	crest length, 375 meters. Dwg. No. OA-23-91						
	Joint-use.					10,222,800	12,267,000
1	Diversion and care of river	Lump sum		Lump sum	41,000		
2	Excavation, stripping borrow pits	9,400	m^3	1.15	10,810		
3	Excavation, all classes, dam foundation	42,000	m^3	1.95	81,900		
4	Excavation, rock, for grout cap	400	m^3	80.00	32,000		
5	Excavation, common, in borrow areas and						
	transportation to embankment	190,000	m^3	2.75	522,500		
6	Earthfill in embankment	170,000	m^3	0.65	110,500		
7	Riprap on upstream slope of embankment	12,000	m^3	11.00	132,000		
8	Bedding for riprap on embankment	6,000		15.00	90,000		
9	Pressure grouting, all work and material	Lump sum		Lump sum	183,000		
10	Furnishing and constructing 20 cm conc. pipe						
	toe drains with open joints	300	lm	21.00	6,300		
	Spillway--Concrete ogee crest 250 meters						
	long. Capacity, 962 m^3/sec.						
11	Excavation, all classes, open cut	105,000	m^3	3.25	341,250		
12	Concrete--inlet and crest walls	1,850	m^3	210.00	388,500		
13	Masonry--crest structure	36,900	m^3	70.00	2,583,000		
14	Concrete--Stilling basin	14,300	m^3	150.00	2,145,000		
15	Reinforcement	877,000	kg	1.00	877,000		
16	Minor items, misc. metalwork, etc.	Lump sum		Lump sum	633,500		
	Subtotal				8,178,260		
	Contingencies (25±%)				2,044,540		
	Field cost--Amarti Dam				10,222,800		
	Engineering and General Expense (20±%)				2,044,200		
	Total est. const. cost--Amarti Dam				12,267,000		
	IRRIGATION DIVERSION DAM--Stone masonry dam						
	with 60 meter ogee spillway; crest length,						
	83 meters; max. height, 5 meters					233,400	280,000
1	Diversion and care of river	Lump sum		Lump sum	8,500		
2	Excavation, common for weir and structures	2,500	m^3	1.95	4,875		
3	Excavation, rock for weir and structures	1,000	m^3	8.00	8,000		
4	Masonry in weir and abutments	1,850	m^3	70.00	129,500		
5	Concrete in headworks and sluiceways	95	m^3	210.00	19,950		
6	Pressure grouting foundations	83	lm	83.00	6,889		
7	Gates, gate hoists, handrails and etc.	Lump sum		Lump sum	9,000		
	Subtotal				186,714		
	Contingencies (25±%)				46,686		
	Field cost--Irr. Diversion Dam				233,400		
	Engineering and General Expense (20±%)				46,600		
	Total est. const. cost--Irr. Diversion Dam				280,000		

TABLE V-3

Project AMARTI-NESHE--Multiple-purpose

Date of Estimate November 1963 — Currency in terms of Ethiopian Dollars

Prices as of January 1961 — (U.S $ 1.00 = Eth $ 2.50)

ITEM NO	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	AMARTI-NESHE--Multiple-purpose					100,762,400	123,020,000
	Joint-use features					(47,545,000)	(57,259,000)
	Power features					(45,617,900)	(56,274,000)
	Irrigation features					(7,599,500)	(9,487,000)
	NESHE DAM--Earthfill; max. height, 60 meters; crest length, 1150 meters; spillway at Amarti Dam. Dwg. No. OA-23-91. Joint-use.					33,222,200	39,867,000
1	Diversion and care of river	Lump sum		Lump sum	52,000		
2	Excavation, stripping borrow pits	130,000	m^3	1.15	149,500		
3	Excavation, all classes, dam foundation	570,000	m^3	1.95	1,111,500		
4	Excavation, rock, for grout cap	1,400	m^3	80.00	112,000		
5	Excavation, common, in borrow areas and transportation to embankment	2,600,000	m^3	2.75	7,150,000		
6	Earthfill in dam embankment	2,300,000	m^3	0.65	1,495,000		
7	Rockfill in dam embankment (transportation of 6 km and placing)	3,100,000	m^3	0.50	1,550,000		
8	Riprap on upstream slope of embankment	110,000	m^3	11.00	1,210,000		
9	Pressure grouting, all work and material	Lump sum		Lump sum	833,000		
10	Furnishing and constructing 20 cm conc. pipe toe drains with open joints	400	lm	21.00	8,400		
11	Furnishing and constructing 30 cm conc. pipe toe drains with open joints	650	lm	37.00	24,050		
12	Access road, 2 lane gravel, Amarti Dam to Neshe Dam. Flat terrain.	5	km	27,000.00	135,000		
13	Bridge across Amarti River below dam	3,300	m^2	270.00	891,000		
	Equalizing Channel--Open cut; length, 935 meters; b = 60 meters; max. cut, 61 meters						
14	Excavation, common	1,000,000	m^3	0.82	820,000		
15	Excavation, rock	1,500,000	m^3	6.50	9,750,000		
	Outlet Works--Capacity, 20 m^3/sec; 1.73 m dia. steel pipe in 3.05 m. horse shoe conduit.						
16	Excavation, all classes, open cut	55,000	m^3	3.25	178,750		
17	Concrete--intake structure	45	m^3	180.00	8,100		
18	Concrete--conduit	1,810	m^3	160.00	289,600		
19	Concrete--gate chamber	165	m^3	210.00	34,650		
20	Concrete--substructure control house	285	m^3	150.00	42,750		
21	Concrete--superstructure control house	30	m^3	210.00	6,300		
22	Concrete--stilling basin	340	m^3	150.00	51,000		
23	Reinforcement	270,000	kg	1.00	270,000		
24	Trashracks	Lump sum		Lump sum	10,000		
25	Slide gates	Lump sum		Lump sum	240,000		
26	Steel outlet pipe	Lump sum		Lump sum	67,500		
27	Minor mechanical & electrical items	Lump sum		Lump sum	17,500		
28	Minor items, misc. metalwork, etc.	Lump sum		Lump sum	70,200		
	Subtotal				26,577,800		
	Contingencies (25±%)				6,644,400		
	Field Cost--Neshe Dam				33,222,200		
	Engineering and General Expense (20±%)				6,644,800		
	Total est. const. cost--Neshe Dam				39,867,000		

TABLE V-3

Project AMARTI-NESHE--Multiple-purpose

Date of Estimate November 1963

Prices as of January 1961

Currency in terms of Ethiopian Dollars

(U S $ 1 00 = Eth $ 2.50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	IRRIGATION CANALS -- Unlined (Continued)						
	North Main Canal -- Length, 29.4 kms; capacity, 3.5 to 2.1 3/sec.					(782,900)	(979,000)
1	Canal excavation, common	158,300	m^3	0.82	129,806		
2	Canal excavation, rock	17,600	m^3	8.00	140,800		
3	Compacting embankment	43,500	m^3	0.98	42,630		
4	Structures	Lump sum		L.S.	263,000		
5	Gates, hoists, valves and misc. metalwork	Lump sum		L.S.	6,265		
6	Concrete pipe	Lump sum		L.S.	12,500		
7	Other miscellaneous work	Lump sum		L.S.	31,300		
	Subtotal				626,301		
	Contingencies (25±%)				156,599		
	Field Cost -- North Main Canal				782,900		
	Engineering and General Expense (25±%)				196,100		
	Total est. const. cost-- North Main Canal				979,000		
	IRRIGATION DISTRIBUTION SYSTEM -- Unlined, open lateral system for 8,490 net hectares on both sides of the Neshe River.					3,502,100	4,377,000
1	Distributuon system served by the South Main Canal. Net hectares.	6,360	ha	330.00	2,098,800	(2,623,500)	(3,279,000)
	Contingencies (25±%)				524,700		
	Field Cost -- Served by S. Main				2,623,500		
	Engineering and General Expense (25±%)				655,500		
	Total est. const. cost -- Served by S. Main				3,279,000		
2	Distribution system served by the North Main Canal. Net hectares.	2,130	ha	330.00	702,900	(878,600)	(1,098,000)
	Contingencies (25±%)				175,700		
	Field Cost -- Served by N. Main				878,600		
	Engineering and General Expense (25±%)				219,400		
	Total est. const. cost-- Served by N. Main				1,098,000		
	DRAINAGE SYSTEM -- Open lateral drains for 8,490 net hectares of irrigated land.					1,485,800	1,857,000
1	Drains for lands served by the South Main Canal. Net hectares.	6,360	ha	140.00	890,400	(1,113,000)	(1,391,000)
	Contingencies (25±%)				222,600		
	Field Cost -- Drains, S. Main				1,113,000		
	Engineering and General Expense (25±%)				278,000		
	Total est. const. cost-- Drains for S. Main				1,391,000		
2	Drains for lands served by the North Main Canal. Net hectares.	2,130	ha	140.00	298,200	(372,800)	(466,000)
	Contingencies (25±%)				74,600		
	Fiedl Cost -- Drains, N. Main				372,800		
	Engineering and General Expense (25±%)				93,200		
	Total est. const. cost -- Drains for N. Main				466,000		

TABLE V-3

Project AMARTI-NESHE--Multiple-purpose

Date of Estimate November 1963

Currency in terms of Ethiopian Dollars

Prices as of January 1961

(U.S. $ 1.00 = Eth. $ 2.50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	POWERPLANT--Hydro					29,797,300	37,247,000
1	Powerplant structure and improvements, masonry and reinforced concrete.	Lump sum		Lump sum	1,980,000	(1,980,000)	
	Waterways					(20,382,300)	
2	Penstocks; welded steel, 2-1.524 meters I.D., 16 to 48 millimeters thick. Two each, 1467 meters long, piers and anchorages, and 2-1.68 m butterfly valves with controls	Lump sum		Lump sum	20,219,800		
3	Tailrace excavation, common	Lump sum		Lump sum	162,500		
4	Turbines and Generators--Two units, 50,000 kva, 13.2 kv, 0.8 pf, 50 cycle generators, and 56,500 English hp, 375 rpm, 560 meter head, impulse-type horizontal turbines.	Lump sum		Lump sum	5,280,000	(5,280,000)	
5	Accessory electrical equipment--All equipment required for control and protection of generators, and station service power.	Lump sum		Lump sum	1,210,000	(1,210,000)	
6	Miscellaneous equipment--Equipment required for general station use.	Lump sum		Lump sum	770,000	(770,000)	
7	Access road--Two lane, crushed rock, from Irrigation Div. Dam to Powerplant.	3.5	km	40,000.00	140,000	(175,000)	
	Contingencies (25±%)				35,000		
	Engineering and General Expense (25±%) Items 1 through 7						(7,449,700)
	TRANSMISSION LINES, SWITCHYARDS, AND SUBSTATIONS					12,093,000	14,563,000
1	Neshe Switchyard--Located near Neshe Powerplant.					(1,831,000)	
	Single breaker line bay, 161 kv, 1,200 ampere, complete.	Lump sum		Lump sum	300,000		
	Single bay, 161 kv, switch installation only, 1,200 ampere, complete.	Lump sum		Lump sum	100,000		
	Three-phase transformers, 50,000 kva, 13.2-93/161 kv, installation complete, two required.	Lump sum		Lump sum	1,431,000		
	Engineering and General Expense (25±%)						(458,000)
2	Transmission line--Neshe Switchyard to Dongi Substation. 161 kv single-circuit steel tower with one overhead ground wire and three 954 MCM ACSR conductors.					(1,408,000)	
	Rough terrain, much clearing	8	km	50,000.00	400,000		
	Average terrain little clearing	24	km	42,000.00	1,008,000		
	Engineering and General Expense (20±%)						(282,000)
3	Transmission line--161 kv Dongi Substation to Gafarsa Substation No. 2 near Addis Ababa. Stringing second circuit on towers included in Finchaa estimate to complete double-circuit line.					(3,224,000)	
	Furnish and install three 954 MCM ACSR conductors.	248	km	13,000.00	3,224,000		
	Engineering and General Expense (10±%)						(322,000)

TABLE V-3

Project AMARTI-NESHE--Multiple-purpose

Estimate November 1963

Prices as of January 1961

Currency in terms of Ethiopian Dollars

(U.S $1.00 = Eth $2.50)

	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	TRANSMISSION LINES, SWITCHYARDS, AND SUB-STATIONS (Continued)						
4	Gafarsa Substation No. 2--Stage 02 (near Addis Ababa), 100,000 kva, 161/132 kv. (See Dwg. 4.0-BN-174)					(4,430,000)	
	Bay Y4	Lump sum		Lump sum	300,000		
	Bay Y2	Lump sum		Lump sum	290,000		
	Bay W4	Lump sum		Lump sum	240,000		
	Bay W5	Lump sum		Lump sum	250,000		
	Reactive control facilities, complete.	Lump sum		Lump sum	1,750,000		
	Autotransformer KY3A and appurtenances	Lump sum		Lump sum	1,600,000		
	Subtotal				4,430,000		
	Engineering and General Expense (25±%)						(1,108,000)
5	Dongi Substation, 161-kv switching between Neshe and Finchaa transmission lines. Two single circuits in, one double circuit 161 kv out.					(1,200,000)	
	Four single breaker line bays, 161 kv complete.	Lump sum		Lump sum	1,200,000		
	Engineering and General Expense (25±%)						(300,000)
	MISCELLANEOUS JOINT-USE FEATURES					4,100,000	5,125,000
1	Access road from Finchaa Project road to Amarti Irrigation Diversion Dam. Rolling terrain.	35	km	40,000.00	1,400,000		
2	Access road from Shanbo-Finchaa River crossing to Amarti Dam. Rolling terrain.	12	km	40,000.00	480,000		
3.	Permanent camps, including offices, shops and housing. Upper and Lower camps.	Lump sum		Lump sum	1,400,000		
	Subtotal				3,280,000		
	Contingencies (25±%)				820,000		
	Field cost--Misc. Joint-Use Features				4,100,000		
	Engineering and General Expense (25±%)				1,025,000		
	Total est. const. cost--joint-use features				5,125,000		

TABLE V-3

TABLE V-4 - ESTIMATED CONSTRUCTION COST SUMMARY
AMARTI-NESHE PROJECT

Feature	In thousands of Ethiopian dollars				
	Total construction cost	Joint-use		Total irrigation features	Total power features
		Power	Irrigation		
Nesha Dam and Reservoir	39,867	30,140	9,727	9,727	30,140
Amarti Dam and Reservoir	12,267	9,274	2,993	2,993	9,274
Power Canal	2,213	---	---	---	2,213
Power Tunnel	2,251	---	---	---	2,251
Powerplant and Penstocks	37,247	---	---	---	37,247
Transmission Plant	14,563	---	---	---	14,563
Irrigation Diversion Dam	280	---	---	280	---
South Main Canal	1,994	---	---	1,994	---
North Main Canal	979	---	---	979	---
Distribution System	4,377	---	---	4,377	---
Drains	1,857	---	---	1,857	---
Access Roads	2,938	2,221	717	717	2,221
Permanent Camp Facilities	2,187	1,653	534	534	1,653
Subtotal	123,020	43,288	13,971	23,458	99,562
Development Cost 1/	3,014	---	---	3,014	---
Total Construction Cost	126,034	43,288	13,971	23,472	99,562

1/See SECTION VIII for details.

12

SECTION VI - IRRIGATION DEVELOPMENT

FINCHAA PROJECT

Introduction

The lands at the lower end of the Finchaa valley west of the river were initially classified and evaluated on the assumption that they would be served in the same manner as the remainder of the project from a gravity diversion at the upper end of the Finchaa valley. Subsequent studies show that this area can be more economically served from water stored in a reservoir on the Neshe River. This reservoir would be located on the plateau area west of the Finchaa valley. Because an important tributary to the Neshe River, known as the Amarti River, flows from the plateau and empties into the Neshe below the escarpment, this portion of the original Finchaa River Project is considered a part of the Amarti-Neshe Project. Lands in the Amarti-Neshe valleys, as well as those near the Finchaa River, are included in the Amarti-Neshe Project. Due to the close integration of the Finchaa Project and the Amarti-Neshe Project plans and the possibilities of irrigation service from either of two sources on some lands, the land resource data are consolidated into a single presentation. That portion of the Amarti-Neshe Project situated in the Amarti-Neshe valleys was only classified by aerial observation, and the data are projected primarily from the information available from the Finchaa valley; therefore, the accuracy of classification of this area is lower than that of the Finchaa valley. The Finchaa Project area is about twice as large as that of the Amarti-Neshe. Separable data on the estimated irrigable acreages for both projects will be presented.

General Description

Location and Extent

The Finchaa Basin occupies an upland valley position in the eastern portion of Wellegga Province near the center of the Blue Nile Basin. The Finchaa River rises in the mountains which lie to the north of the Addis Ababa-Lekkemt highway between the Guder

River drainage and the village of Baco. The tributaries flow generally northward into the Chomen Swamp, a vast flat area on the plateau lying between the mountains and the precipitous escarpment forming the northern limit of the plateau. The river leaves the swamp and plunges abruptly over the escarpment, which is several hundred meters high. It then flows through the Finchaa valley and tumbles downward through some rough terrain to its confluence with the Blue Nile River.

The Finchaa valley lies in a box-like canyon about 12 kilometers wide and 37 kilometers long. It is bounded on the south, east, and west sides by high, nearly vertical escarpments at the edge of the relatively flat upland plateau approximately 750 meters (2500 feet) above the valley floor. Low hills near the lower end of the valley form the western boundary, which separates the Finchaa and the Amarti-Neshe drainageways.

The Finchaa and Amarti-Neshe River valleys are contiguous with each other and are located within the general boundaries of latitude 9° 35 minutes to 9° 55 minutes North and longitude 37° 15 minutes to 37° 28 minutes East.

Physiography

The Finchaa valley slopes to the northward at an average rate of slightly less than one percent, and the land areas on either side of the river slope to the center at an average rate of about two percent. The project lands are dissected by many tributary channels varying in depth from shallow swales to vertical cuts of 20 meters or more. The stage of erosion indicates a young or very early maturity type of topographic surface.

Although no data are available on the Amarti-Neshe valleys, it is probable that these valleys are ancient alluvial depositions overlying metamorphic rock. These valleys have a dendritic type erosional pattern similar to the Finchaa valley.

Transportation and Habitation

Both the Finchaa and the Amarti-Neshe River valleys are uninhabited and uncultivated. There are a few foot and game trails, but no roads exist. The nearest all-weather market road is at Gedo, approximately 60 kilometers from the upper end of the Finchaa valley. The escarpment which virtually surrounds the Finchaa valley is about 750 meters high and will create a problem in any attempt to construct a road from the plateau to the valley. The plateau areas adjoining the Finchaa and the Amarti-Neshe River valleys are inhabited, and much of this area is cultivated.

Present and Potential Land Use

The vegetative cover over the project areas consists of a fairly dense growth of tropical savannah woodland, typified by acacia, fig, and other varieties of deciduous trees and shrubs, interspersed with a very dense growth of tall grass. With the exception of trees growing in the stream bottoms, which often reach a height of about 30 meters (100 feet), the usual trees on arable land attain a maximum height of about 9 meters (30 feet) and a maximum diameter of about 1/2 meter (20 inches). An occasional area of grass occurs, occupying a rather flat or lowland position, but these areas comprise a small percentage of the total area. Seasonal burning of the grass is practiced.

A large variety of crops could be grown because of the long growing season. However, the cool nights limit the production of some crops. The most likely crops under irrigation would include coffee, corn, sorghum, field beans, tobacco, peppers, castor beans, flax, and other oilseeds. Some subtropical fruits could be grown if desired.

Tsetse flies and mosquitos are common throughout these valleys, and it is probable that malaria would be a problem requiring attention for the successful operation of an irrigation project.

Project Lands

Topography and Land Development

As previously indicated, the Finchaa and the Amarti-Neshe River valleys are dissected by their respective river channels and each valley has numerous, well incised tributary channels. The tributaries are usually entrenched into the valley soils from 2 to 15 meters or more.

Irrigation development will be faced with several problems associated with the present land use and topography. Clearing the land of brush and trees will be a prerequisite to any type of irrigation development. Based on prices for clearing in the United States and Africa, the estimated average clearing costs will be about Eth$230 per hectare. It seems likely that much of the wood could be used for household purposes, such as fuel, charcoal, and brush fences.

The slope of the valley is greater than would be desired for control of erosion, but it lends itself readily to water spreading with minimal expense for land leveling. Only a small portion of the

12

land has slopes less than 1 percent. It is estimated that leveling costs for minimal land development would be about Eth$125 per hectare.

The arable lands occur on the ridges and side slopes of a valley plane dissected by a well entrenched dendritic type immature drainage pattern. The tops of the ridges generally vary in width from 300 to 1,000 meters, and are usually from 1 to 2 percent in slope. On both sides of these ridges the land increases in slope to the bottom of the drainages. Side drainage from each ridge creates problems for water distribution. A substantial portion of the arable land area has slopes of 2 to 8 percent and there is also a considerable acreage of land with slopes 8 to 12 percent. Because of the subreconnaissance nature of the classification and the scale of the base maps, a considerable acreage of nonarable topography in and immediately adjacent to the drainageway was included in the arable delineations. More refined classifications will exclude most drainageway as nonarable. Further study is needed to determine the maximum slopes permissible for irrigation under the local conditions. Erosion hazards may require that lands with steep slopes be declared not suitable for irrigation. Slopes up to 12 percent were included as arable in this classification.

Although the slope of the land and the erosive nature of the soil are best suited to irrigation by sprinkler procedures and there is sufficient natural slope to develop gravity pressure for this type of system, engineering and other considerations indicate that a simple, gravity type, irrigation system, utilizing contour ditches, will be most practical at this stage. The gravity method is a good first step to more refined irrigation system. Basin type irrigation with adequate drop structures to control surface wastes from rain and irrigation may be considered as an ultimate goal.

Disposal of rain and irrigation wastes could be an important problem in this project. Although there are a great number of natural wasteways, the erodibility of the soils and the steep slope of the lands are such that without proper wasteways the erosion could develop numerous, deep, vertical walled drainageways that would wash away the soil resources and increase the costs for operating and maintaining the project.

Although most of the tributary drainages are well incised, it is possible that drainage waters emanating from the adjacent plateau areas could damage canals or other irrigation facilities during periods of unusually high runoff unless care is taken to assure that irrigation facilities are designed to accommodate such floods.

12

Drainage

Natural surface drainage facilities are generally excellent to excessive. Excess surface waters will quickly find a natural drainage channel for return to the river. However, as indicated in the foregoing discussion of the topography, such surface wastes could cause serious erosion problems unless suitable erosion control drop structures or well grassed drainageways are provided. This erosion problem could result in a substantial land development cost in areas where erosion hazards are worst. In some of the larger tracts, the surface wastes can perhaps be kept on the ridges for reuse to minimize this problem.

Because of the slope and generally permeable nature of the soil in association with the numerous, deeply entrenched, natural drains, adequate control of a water table under irrigation appears feasible. However, the underlying basalt in the project area is believed to be less fractured and less permeable than that which occurs in the high plateau areas, so very little percolation through the basalt can be anticipated. Prior to construction, detailed drainage studies should be made. This should include a study of the existing water table behavior, a study to determine if any dikes occur that would impound ground water, an evaluation of present vegetation for evidence of wet areas, and suitable pump-in tests to determine the in-place permeability. Studies on the need for and location of erosion control structures in present drainageways are also needed.

Soils

The red latosols occupy the bulk of the project areas. These soils are typical of those developed under well-drained conditions in tropical or subtropical areas. They have a deep and generally freely drained profile. The clay fraction usually has a high percent of kaolinite and lesser amounts of illite clay minerals. They have a low cation exchange capacity, low base saturation, and considerable acidity. A common characteristic of these soils is a high phosphate fixation.

Although the latosols are low in plant nutrients, they have physical properties well suited to irrigation. They are normally well aerated and they can be cultivated over a wide range of moisture conditions. The soil textures are usually clay. However, the nonexpanding type minerals in these soils result in a physical condition about like a loam soil with expanding type clay minerals. Soil crusting is not common.

Mulching of latosols is usually advocated for maximum production. Such mulches as banana leaves or elephant grass can be used to cover the soil where the growing crops are not grown to improve productivity. This treatment tends to reduce the soil temperatures, reduce evaporation, and maintain a favorable soil structure. This treatment should be a goal for future management of the project soils under irrigation.

Grumusols occupy a small percentage of the Finchaa and Amarti-Neshe valleys. These soils have quite different properties than the latosols. The obvious difference is that grumusols are black as compared to the red color of the latosols. For this reason, these two soils are often called "black" or "red" when discussing tropical or subtropical soils.

The grumusols are composed of swelling-type clay minerals such as beidellite or montmorillonite. Therefore, these soils crack badly at the surface when drying. Grumusols usually develop in a warm humid climate where there is a large supply of calcium carbonate or where subsurface drainage conditions are restricted. They are usually neutral to alkaline in reaction and are relatively low in organic matter, even though their color is nearly black. When moistened, the clay swells and the soil becomes sticky, plastic, and almost impervious. Low productivity is usually due to these adverse physical features rather than to the inherent fertility or lack of it. Grumusol soils are rich in lime, but are usually low in phosphorous and nitrogen. They are usually more susceptible to erosion than the latosols, but both soils erode rather easily.

It seems probable that the soil materials in these project areas were deposited in the valleys from the high plateau areas at an early stage of geology following the volcanic eruption that resulted in the basalt flow. Although the soils are mostly latosols and generally fine textured, there are considerable variations within the soils locally.

Near the escarpments on either side of the Finchaa valley, the soils are strongly influenced by the high, massive sandstone formations. Soils tend to be coarser near these escarpments and in the upper half of the project than they are near the river or in the lower half. Although a few sandy loam or coarser soils exist near the escarpment, the predominant surface textures are sandy clay loam, clay loam, and light clay. Below 45 cm the subsoil textures are clays in most instances. The soils are all quite erosive and great care will be needed to prevent deep headcuts and ravines from developing.

A typical latosol profile consists of 15 cm of dark reddish-brown, nonsaline, noncalcareous sandy clay loam, with a pH of about 5.2. From 15-45 cm is dark red clay which has a pH of near 6.0. Red friable clay having a mildly acid reaction occurs below 45 cm to bedrock. The profile has a feeling of much lighter texture than the clay textural description, because the clays are nonsticky. These soils are friable, very permeable, and well suited for irrigation.

Sandstone cobbles occur on the surface of some soils, particularly in the upper part of the Finchaa valley and also near the escarpments. Basalt cobbles also occasionally occur in some soils, but are not believed to be any hindrance to irrigation development.

In the lower half of the Finchaa valley and in the Amarti-Neshe Project, the soils are mixtures of latosols and grumusols with a large predominance of latosols. The soil textures in these areas tend to be finer throughout the profile than in the upper part of the Finchaa valley, and the soils are all less friable and permeable than the soils in the upper basin. The grumusol soils crack when dry, and are quite sticky when wet. Permeability is low in such soils and greater skill will be needed in farming than in the latosol soils. Trees do not grow well in the grumusol soils, and these soils usually have only a grass cover under present conditions.

Land Classification

The subreconnaissance land classification of the Finchaa Basin was accomplished during the rainy season by use of helicopter, because of the inaccessibility of the valley by other forms of transportation. The mapping was done on 1:50,000 contact aerial photographs. Traverses were spaced at about 1 kilometer intervals and landings were made wherever possible. Owing to the dense forest cover, the only treeless spaces available for landings were the small areas of black soil or an occasional gravel bar on the Finchaa River. From these landings it was necessary to travel through the dense underbrush and tall grass on foot to appraise the various soil conditions. Under these conditions, most of the land appraisals necessarily had to be done from the helicopter without the benefit of soil borings and careful morphological studies. It is recognized that there will likely be a considerable reduction in acreage suitable for irrigation when detailed studies are made. Although it is believed that most soil conditions are reasonably favorable for irrigation, topographical conditions are less favorable. Detailed studies will eliminate some

rough lands--particularly drainageways--which are presently not separated as nonarable. Because of the rough nature of the classification and the inability to study the variations of the land class determinating factors, only two arable land classes were delineated. These were Classes 2 and 3. Detailed studies may show that considerable Class 1 land exists. The standards used in classifying these lands are shown in Table VI-1.

Class 2 lands within the project areas consist of deep, friable, permeable, well drained, latosol soils. Slopes are usually in the range of 1-3 percent, but a few areas of slopes to 7 percent are included. Nearly all of these lands are covered with grass, brush, and trees which must be removed prior to irrigation. A small amount of rock removal will also be needed on some lands. After they are developed for irrigation, Class 2 lands will be capable of growing any climatically adapted crop if properly managed. These soils are inherently low in fertilility and will require commercial or animal fertilizer if full production is to be achieved. The Class 2 lands represent 67 percent of the arable land, and are placed in this class mainly because of topographic deficiencies.

Class 3 lands generally are the lands which occupy the side slopes of the numerous drainageways, but also include some rougher, rolling type topography, some stony lands, and the areas of grumusol soils which were observed. The greater portion of Class 3 lands has a slope ranging from 5 to 12 percent. These lands generally have more and larger trees than the Class 2 lands, will be more difficult to farm, and will be less productive. Although most of the soils are latosols and are well adapted to diversified crop production, the steeper slopes and greater danger of erosion are such that these lands require better management than the Class 2 lands. More grass and close growing crops and fewer cultivated crops should be used on these lands than on the Class 2 lands. Class 3 lands occur on 33 percent of the arable area. It can be anticipated that a portion of these lands will be classified as nonarable in a detailed study.

Class 6 lands include some excessively stony lands, the steeper and rougher drainageways, and other complex, rough topography. These lands total approximately 10 percent of the gross area classified.

The results of the classification are set forth in Table VI-2, and the location of the lands is shown on Drawings No. 7.1-Fi-3 and 2.0-Fi-13.

TABLE VI-1

SUBRECONNAISSANCE LAND CLASSIFICATION STANDARDS--BLUE NILE BASIN

Land characteristics	Class 1--Arable	Class 2--Arable	Class 3--Arable	Class 6--Nonarable
Soils				
Texture	Sandy loam to friable, very permeable non-plastic clay	Loamy sand to friable, permeable nonplastic clay	Loamy sand to plastic, slowly permeable clay	Sand and gravel
Minimum depth (cm)				
to bedrock	150	105	75	<75
to volcanic tuff	120	90	60	<60
to clean sand, gravel, or cobble	90	60	45	< 45
Topography				
Permissible slope				
Uniform	0 - 3.0%	3.1 - 7.0%	7.1 - 12.0%	>12.0%
Nonuniform	-	0 - 3.0%	3.1 - 7.0%	> 7.0%
Surface leveling	Smoothing only	Moderate grading	Heavy grading	Very heavy grading
Clearing of rocks or vegetation	Low cost	Moderate cost	High cost	Very high cost
Drainage				
Anticipated cost	Low	Moderate	Moderate	High

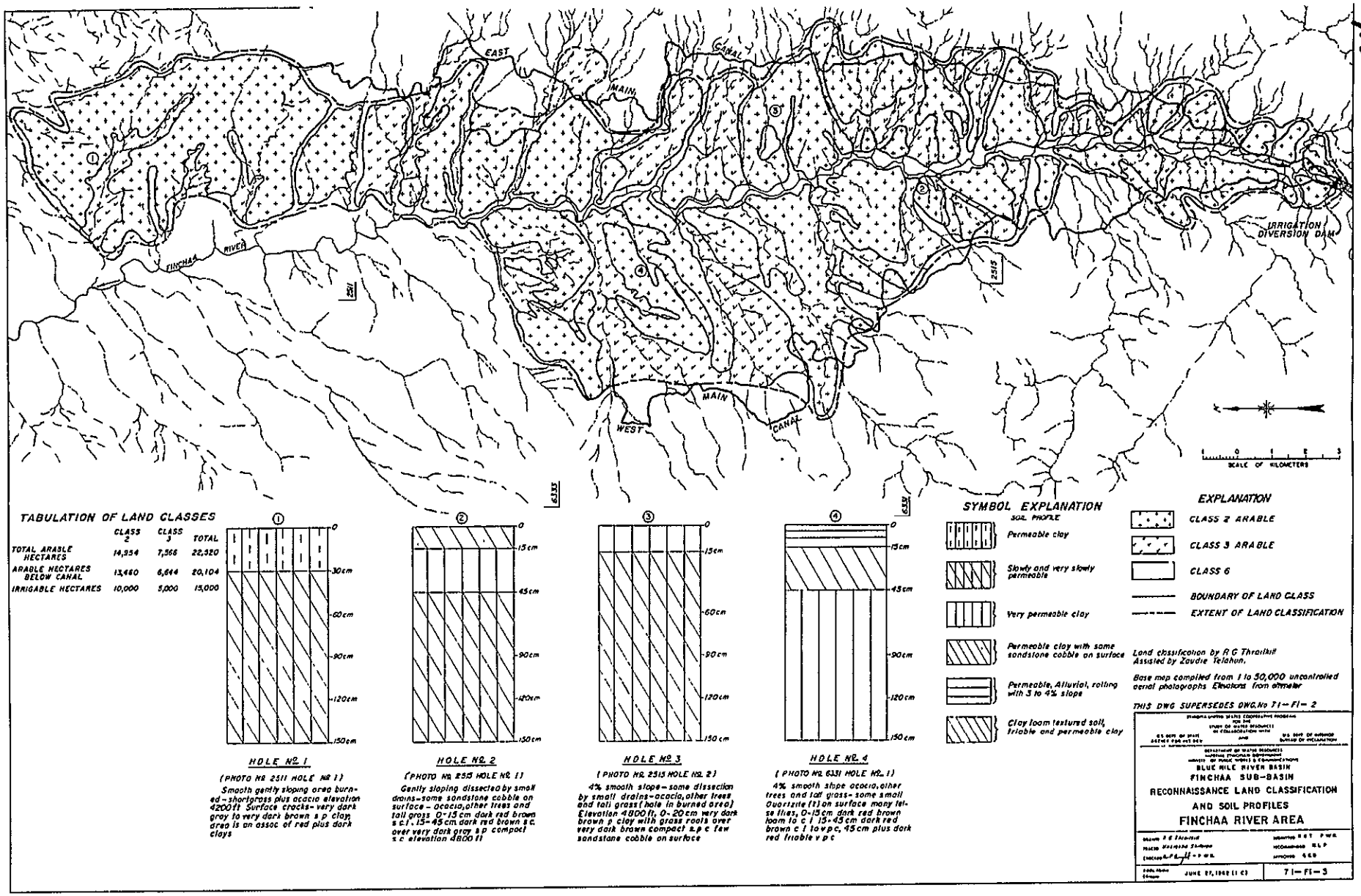
13

TABLE VI-2

ARABLE AND IRRIGABLE AREAS--FINCHAA AND AMARTI-NESHE PROJECTS

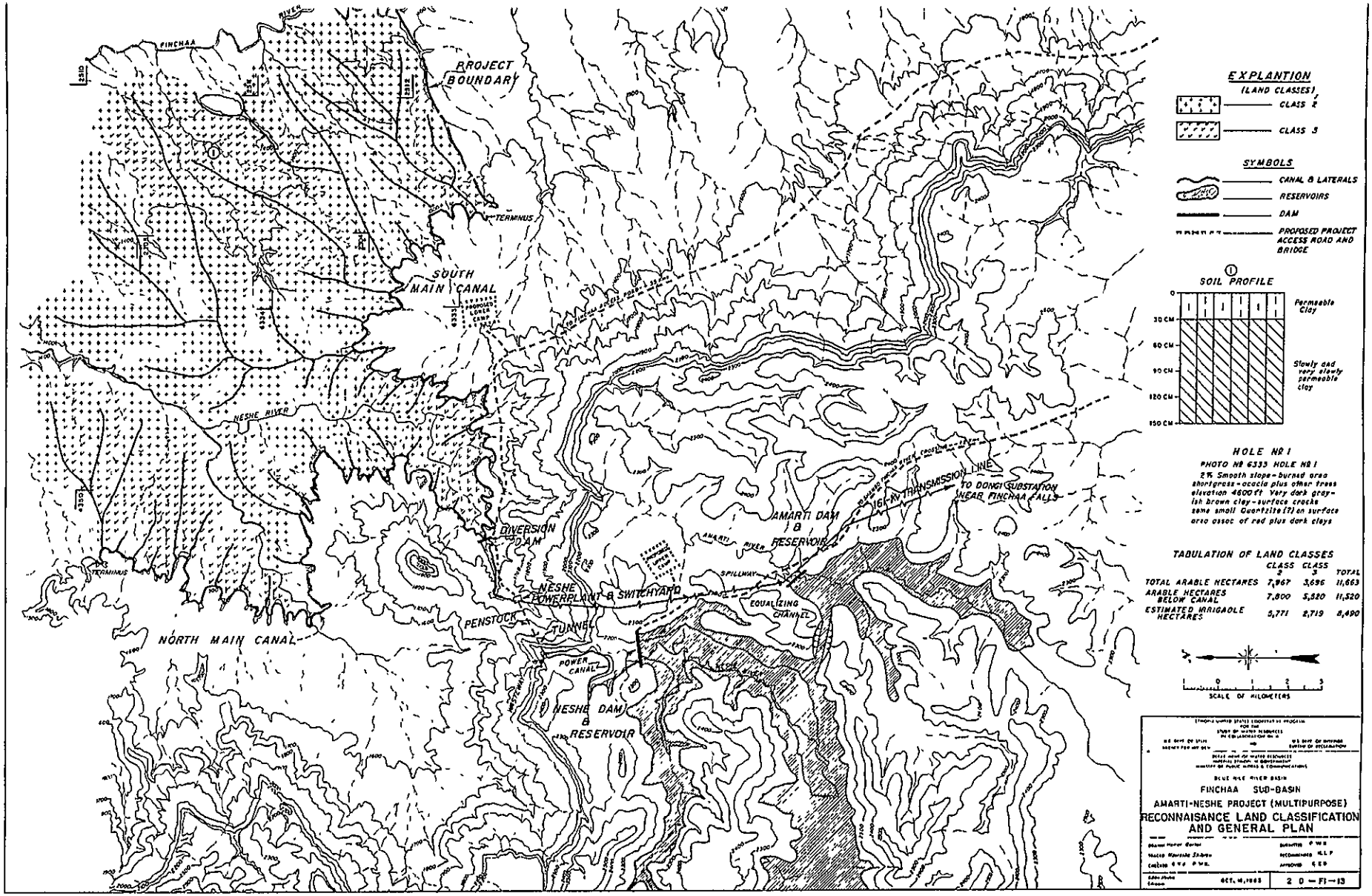
Project	Land type	Land class areas (hectares)			
		1	2	3	Totals
Finchaa	Total arable	--	14,954	7,566	22,520
	Arable below canal	--	13,460	6,644	20,104
	Irrigable	--	10,000	5,000	15,000a/
Amarti-Neshe	Total arable	--	7,967	3,696	11,663
	Arable below anal	--	7,800	3,520	11,320
	Irrigable	--	5,771	2,719	8,490a/

a/Based on estimate that 75 percent of arable land below canal will be irrigable.



BEST AVAILABLE COPY

BEST AVAILABLE COPY



Agricultural Economics

Agricultural Conditions before Project Development

At present the Finchaa valley, including the sites of the proposed Finchaa and Amarti-Neshe Projects, is uninhabited, uncultivated, and ungrazed. Therefore agricultural production in the area can be said to be nil. All returns from future project development are considered to be increases to the economy, because no pre-project income exists.

Agricultural Conditions after Project Development

Anticipated Cropping Pattern during Irrigation Season. The Finchaa valley, with its low elevation and mild climate, is considered suitable for growing a wide variety of crops. Frost is not a danger, and many subtropical and temperate crops should do well there. However, the area is thought to lie too low, and to be too warm, for the optimum growth of some of the staples of the Ethiopian diet. These include barley, chick peas, lentils, noog, and teff.

The crops that are anticipated reflect both the dietary patterns of the Ethiopian population, and the concept of commercial production for the market. Some of the traditional staples--corn, sorghum, field beans, flax seed and mustard, coffee and peppers--are included, both for use by the project population and for shipment to the central market. And such crops as tobacco, castor beans, and sunflower are projected for both central marketing and export.

One new crop, buckwheat (Fagopyrum esculentum), appears in the projection on a small scale. It is a cereal-like grain which produces a head that can be hulled and ground for flour. Bread made from this flour does not rise, but instead forms a type of pancake or a flat bread similar to the teff or sorghum "injerra" much favored by Ethiopians.

In a test held at the agricultural high school at Jima, flat bread prepared from buckwheat was found palatable by Ethiopians who ate it. Since no teff is projected for the Finchaa area, buckwheat may be a partial substitute. The crop appears adaptable for Finchaa conditions and should yield well.

Corn (maize) and sorghum are two traditional grains grown in Ethiopia, and in many parts of the world. In Ethiopia, corn (Zea mays) is roasted or cooked in stew, or "wat", but generally not ground for flour. The varieties grown on the project should be

selected for suitability for grinding, to introduce this use on a larger scale. Sorghum (Sorghum vulgare) is an indigenous grain used for "injerra," for local beer or "tulla", and roasted. It is a staple of the Ethiopian diet, eaten frequently in many areas. Haricot beans, also called field or navy beans (Phaseolus vulgaris), which resemble small lima beans, are eaten in "wat"; as fresh vegetables; are ground and cooked as a type of porridge; or are roasted. Small quantities are exported for cattle and poultry feed. Peppers (Capsicum annuum and C. frutescens) are a hot species used both as vegetables and as spice. The mature pods are ground and mixed with a combination of other spices and used to flavor the "wat"; cooked whole or in sections in the "wat"; or consumed fresh as a green vegetable. They are eaten daily by the bulk of the population. Mustard (Brassica nigra) and flaxseed (Linum usitatissimum) are two edible oilseeds that are projected for the irrigation season. Both are thought to be indigenous to Ethiopia. The seeds are crushed on the dish in which "injerra" is cooked; added to "injerra" in the dough stage; added to "wat"; used as a salad oil; and manufactured into soap. Flaxseed is also eaten with spices and taken with water for therapeutic purposes. Small amounts of both oils are exported. Coffee (Coffea arabica), supposedly indigenous, is the leading export crop of Ethiopia, and has many domestic uses. The beans are ground to produce the beverage or eaten as cakes; and the skin of the berries is used as a vegetable.

Ethiopian coffee intended for export is subject to quality control by the Ethiopian Coffee Board. Finchaa coffee that is grown, picked, and handled under controlled conditions should be higher in quality than the coffee grown and harvested under the usual "wild", or coffee forest conditions, and should find a place in both the domestic and the export markets.

Crops suggested entirely for commercial usage, with no consumption on the project before processing, include tobacco, castor beans, and sunflower. Tobacco (Nicotiana tabacam), variety Oriental or Turkish tobacco, has been grown in Ethiopia for several centuries. It is produced on a small scale at the present time, but the demand for cigarettes and other tobacco products is expanding. Tobacco products are manufactured by the Imperial Tobacco Monopoly, which presumably would be the outlet for Finchaa leaf. The Oriental variety is better adapted to Blue Nile elevations than the Virginia variety, also grown in Ethiopia. It has smaller leaves, is highly aromatic, and burns quite easily.

The castor bean (Ricinus communis), a plant indigenous to Ethiopia, yields a nonedible, poisonous oil that is used to lubricate jet engines and has usage in the textile, leather, and cosmetic industries. The Finchaa crop is intended for export, but if specialized industry develops in Ethiopia some portion of the crop may eventually be used at home.

Sunflower (Helianthus annus) yields an edible oil that is little known in Ethiopia at the present time, but has many uses overseas. The oil is used in salads, for cooking, as a butter substitute in its solid form, for soap, and as an industrial lubricant. The oilmeal is a valuable cattle feed and a nitrogenous fertilizer, and the whole seed may be consumed by human beings or fed to poultry.

Data on the yield of crops adapted to irrigated conditions in Ethiopia are not readily available. Measures of yield and units of land are seldom known or reducible to a common denominator. Irrigation, as practiced by the average Ethiopian farmer, is an operation which produces a few staple crops and a very limited number of specialty food crops. Observation and survey data indicate that monetary returns under present irrigation do not greatly exceed nonirrigated returns, because of many limiting factors. These include poor distribution of available irrigation water, dependence upon streams with variable flows, a low level of fertility, a low rate of germination due to poor seed, uneven covering of the seed, an uneven and often low plant population, inefficient cultivation, and other negating factors. Therefore, it is not possible to project future yields on the basis of present subsistence irrigation data.

As a basis for estimating crop yields, data were gathered from a wide variety of sources. Estimates were prepared from existing secondary data, which were sparse in detail, and checked with agronomic advisers and agricultural research technicians. Primary yield figures were gathered wherever possible. Most were obtained at the Azienda Agricola in Wello, at the Wonji sugar estate in Shewa, the experimental station at Bishoftu, and from projected figures for the Metahara plantation on the Awash River.

To adapt these scattered figures to expected Blue Nile conditions under project development, the influence of climate was considered most important. The factors which constitute climate, particularly temperature minima and maxima, and frost probability are considered in this report to be functions of elevation. As elevations increase, the daily minimum and maximum temperatures decrease. Frost may occur at the higher elevations within the range of irrigation response. Observations made in the Blue Nile Basin give support to the theory that the time required for plant maturity increases with elevation, and generally that yields are depressed in direct relation to increased elevation. This relationship, believed to exist between crop yields and elevation, has been arithmetically applied to future project areas.

Blue Nile proposed project areas have been placed into elevation categories. The lowest category covers the range from 600 to 700 meters, the second from 700 to 1500 meters, the third

from 1800 to 2000 meters, and the highest covers areas above 2000 meters. No projects are planned below 600 meters, between 1500 and 1800 meters, or above 2200 meters.

The relationship of yield to elevation is plotted in a direct progression. Each successively higher elevation category shows a yield reduction of 15 percent, each lower category an increase of 15 percent. The Finchaa area lies at 1500 meters, and the second highest group of yield is applied.

In this analysis no distinction is made for yields on different land classes. Many variables are encountered, and more reliable data must be available before a supportable estimate can be made for a distinction of this type. Since the data on irrigated crop yields are so scanty, it does not appear prudent to refine the estimates further. A more detailed study, however, may justify differentiation of yields by land classification.

It is recognized that many of the factors influencing crop yield need testing on experimental fields before more refined predictions are possible. Indigenous crops may respond successfully to irrigation, but imported varieties may respond even better. Alternative crops will be developed largely by test and experimentation. Fertility levels, frequency and amount of irrigation, and level of soil acidity are only a few of the factors related to irrigation and mechanization which need testing and which may appreciably modify preliminary yield expectations. Furthermore, the length of day and the hours of sunshine per day may alter the expected response of imported crops.

The assumption has been made that the irrigation season would commence in October and extend to June. Although this period provides a growing season longer than most crops will require, only one planting of each crop is projected for this study. This is done to avoid overstatement of expected monetary returns. But, during actual operations, particularly some years after operations have commenced, replanting with short-season crops would probably follow harvest of the first crops.

The responsibility for a second crop is left to the project. If the cropping pattern is followed, monetary benefits should equal those projected. But if a second planting is made, fuller utilization of the land should result in higher cash returns than are projected.

Anticipated Cropping Pattern during Nonirrigation Season. A second group of crop projections is necessary to determine the response of crops produced without irrigation on Blue Nile Basin

projects. For cropping purposes there are two seasons in the Blue Nile Basin areas--the irrigated season, which extends roughly from October 15 to June 1; and the rainy or nonirrigated season, which covers the rest of the year. During the irrigation season many mechanical practices can be introduced and the amount of water applied to the land strictly regulated. During the rainy season, however, the precipitation falling on the fields is uncontrollable, daytime temperatures are lower, the sun shines fewer hours per day, and yields are understandably lower than levels expected in the irrigation season.

Physical difficulties are also greater in this season. The concentrated heavy rainfall frequently prohibits the use of tractors and other mechanical equipment while muddy fields increase maintenance costs. Therefore, the combination of poor returns, higher operating costs, and difficulty of access to fields places many operations out of the question in this season.

The best solution may be to utilize the land approximately in the way it is used under pre-project conditions in Ethiopia. This is preferable to keeping it fallow for four and one-half months of each year. The fields should be plowed and disked by tractors before the onset of the heavy rains, and sown in short-season, fast-maturing crops, such as certain grains, pulses, and oil seeds. These should be cultivated by hand, mature, and be harvested before the land is plowed for the major irrigation season operations. In addition to fuller utilization of the land, a certain amount of food would be produced, and farmers would be utilized on a year-round basis.

A possible detrimental effect of rainy season farming is damage to the soil tilth caused by working the soil when it is wet or puddled. However, the reddish latosols, which predominate in the Finchaa valley, are much lighter and less plastic than the dark gray clays which abound in many other project areas, and would present less of a problem in this respect. Any soil damage that does occur should be assessed against the value of the foodstuffs produced during the rainy season.

The list of crops suggested for the Finchaa rainy season is confined to corn, millet, haricot beans, and mustard. These crops are all well known and accepted in the basic diet. Coffee, which is projected for five percent of the area, is a perennial crop that may require some cultivation during the rains, but should not be considered an off-season crop.

14

All crops projected for the rainy season, except millet, are described earlier. African millet or dagussa (Eleusine coracana) is a grain indigenous to Ethiopia and is used on a small scale for "injerra", cereal cakes, roasting, and "wat". It is included to supplement the production of irrigated cereals.

Nonirrigated crop yields are based largely on known yields recorded in sample surveys conducted in Shewa, Wellegga, and Gojjam Provinces. Figures are adjusted by elevation in the same manner as the irrigated crop yields. However, although the nonirrigated crop yields are much lower than irrigated yields, they are projected higher than those presently realized in Ethiopia, to allow for the effects of management, fertilizer, lime, and superior seed.

In the nonirrigation season, 75 percent of the land is expected to be cultivated, compared to 95 percent in the irrigation season. This will allow for some late harvest of irrigated crops, and for the minority of farmers who would prefer to regard the rainy season as a period of unpaid vacation.

Crop Prices. Prices of the crops that will be produced on the Finchaa Project are based upon Addis Ababa or central market, wholesale prices, reduced to reflect the distance from the project area to the central market. Addis Ababa prices for the various commodities, collected for the 1956-1960 period, are essentially the prices paid to the primary producer, plus the cost of hauling. For project purposes a standard reduction factor of Eth$0.80 per 100 kilograms per 100 kilometers of distance is used. This factor was constructed from hauling rates used in Ethiopia in the recent period.

Although a lower rate is found in some parts of the Empire, hauling to the Finchaa area will probably always be expensive due to natural topographic conditions. Produce must move up a steep incline onto the escarpment before it can reach the main road at Gedo.

Prices applicable to the Finchaa Project are listed in Table VI-3. Since the area lies approximately 300 kilometers from Addis Ababa, central market prices are reduced by Eth$2.40 per 100 kilograms. It is assumed that all of the produce sold off the project will be transported to the central market, although it is possible that some yet-unknown quantity will reach other markets for distribution.

TABLE VI-3. WHOLESALE PRICES IN ADDIS ABABA AND IN THE FINCHAA AREA

Commodity	Addis Ababa Eth$/100 kg.	Finchaa area Eth$/100 kg.
Buckwheat 1/	12.00	9.60
Corn	12.58	10.18
Millet (dagussa)	12.30	9.90
Sorghum	16.10	13.70
Haricot (field) beans	18.92	16.52
Flaxseed	23.54	21.14
Mustard	20.15	17.75
Castor beans	29.02	26.62
Sunflower	28.00	25.60
Coffee	164.24	161.84
Peppers (berberi)	58.33	55.93
Tobacco (Oriental)	117.00	114.60

1/ The price for buckwheat is conjectural; no buckwheat is grown in Ethiopia today. The prices for cereals, beans, oilseeds, and coffee include hulling but not cleaning. Pepper and tobacco prices are those for the dry fruit and the dry leaf, respectively.

Summary Sheets. Tables VI-4 and VI-5 are designed to show the agriculture of the Finchaa Project in terms of crop production and of the gross income to be realized from the sale of crops. Table VI-4 shows the returns on the basis of an average 100 hectares, Table VI-5 on a full project, 15,000-hectare basis.

The first portion of each table is intended to show the pattern of cropping, crop yields, crop prices, and income for the area under present conditions. The area is uninhabited and has no present agriculture, therefore only the price column is used, because crop prices are applicable for future as well as present conditions.

The remainder of the tables shows expected conditions under irrigation development. Hectares of each crop, yield per hectare, total crop production, and monetary returns for crops sold are listed.

The total monetary return for the irrigation and nonirrigation seasons is the gross crop income for the area. Since there is no present agricultural income, total future income is considered to be incremental to development of the project.

Under operating conditions the average size of farm in the project area will be 17 hectares (see SECTION IX, Administration and Operation). The average farmer will be farming sixteen hectares during the irrigation season, and using one hectare for the farmstead, farm roads, and woodlot. During the nonirrigation season fifteen percent of the land is expected to lie fallow, so that at this time the average farmer will be cultivating thirteen hectares.

Consumption of Crops. The production of crops in the Finchaa area after project development, shown in kilograms, may also be expressed in nutritional terms. The content of the average Ethiopian diet is known, and is stated to be low in calories, 1/ and inadequate in vitamin A and ascorbic acid. 2/ Improvement of the diet of project residents will be one of the real benefits of developing the Finchaa area. It is assumed that sufficient food will be available for project residents; beyond that, a surplus will be available for sale in the domestic and export markets of Ethiopia.

An average daily intake of 2,900 calories per person is thought to be sufficient, considering the type of work, the climate, and the height and weight of the population. Approximately 85 percent of this requirement will be met by project foodstuffs; the remainder, which is contributed by false banana, onions, potatoes, cabbage, sugar, minor spices, vegetables and fruit, and meat and livestock products, is not scheduled for immediate inclusion in the cropping pattern (see Livestock and Alternative Crops). Therefore, about 2,460 calories per day would originate on the project and the balance of 440 calories per day from other sources. This would assure a diet that is adequate in quantity, and possibly also better balanced. Yearly project consumption of calories under ultimate conditions would be 2,460 per person multiplied by 65,000 people by 365 days per year, or 58,400,000,000 calories. The remainder produced, some 84,463,000,000 calories, will be available for sale.

1/ "The average dietary intake is approximately 2,500 calories. It can be estimated that there may be an average calorie deficit of up to 400 calories per person daily." General Review of Health and Medical Problems in Ethiopia, Weh-Pin Chang, World Health Organization

2/ Ethiopia Nutrition Survey, A report by the Interdepartmental Committee on Nutrition for National Defense, September 1959, p. 40.

14

CROP PATTERN	CONDITIONS E		
	CROP 1/ DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg
Buckwheat	-		
Corn	-		
Millet (dagussa)	-		
Sorghum	-		
Haricot beans	-		
Flaxseed	-		
Mustard	-		
Castor beans	-		
Sunflower	-		
Coffee	-		
Peppers	-		
Tobacco (Oriental)	-		
Subtotal, Crops	-		
Fallow	-		
Subtotal, Cultivated area	-		
Noncultivated irrigable land	100.0		
Total area	100.0		

1/ This project area is uninhabited at present.

TABLE VI-4 . Summary of Farm Income for Estimating Benefits by Us
Finchaa Project, Ethiopia, on a 100-hectare Basis

ORE PROJECT		FUTURE CONDITIONS, IRRIGATION S				
ICE RECEIVED ER 100 Kg Eth.$	INCOME Eth.$	CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	SHIPMENT TO CENTRAL MARKET Kg	VALUE OF SHIPMENT TO CENTRAL MARKET Eth.$
9.60		5	2,000	10,000	7,500	$ 720
10.18		15	3,175	47,625	41,825	4,258
9.90		-	-	-	-	-
13.70		20	2,980	59,600	36,100	4,946
16.52		10	1,780	17,800	17,800	2,941
21.14		5	1,000	5,000	5,000	1,057
17.75		5	1,170	5,850	5,850	1,038
26.62		10	2,000	20,000	20,000	5,324
25.60		10	1,800	18,000	18,000	4,608
161.84		5	960	4,800	4,100	6,635
55.93		5	920	4,600	2,100	1,175
114.60		5	2,000	10,000	10,000	11,460
		95				44,162
		-				-
		95				44,162
		5				-
		100				44,162

Estimating Benefits by Use of the Gross Crop Income Method, on a 100-hectare Basis

ONS, IRRIGATION SEASON				FUTURE CONDITI	
SHIPMENT TO CENTRAL MARKET Kg	VALUE OF SHIPMENT TO CENTRAL MARKET Eth $	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth. $	CROP DISTRIBUTION ha	YIELD Kg/ha
7,500	$ 720	2,500	$ 240	--	--
41,825	4,258	5,800	590	30	1,180
-	-	-	-	25	975
36,100	4,946	23,500	3,219	--	--
17,800	2,941	-	-	10	950
5,000	1,057	-	-	-	-
5,850	1,038	-	-	10	700
20,000	5,324	-	-	-	-
18,000	4,608	-	-	-	-
4,100	6,635	700	1,133	5	-
2,100	1,175	2,500	1,398	--	--
10,000	11,460	-	-	-	-
	44,162		6,580	80	
	-		-	15	
	44,162		6,580	95	
	-		-	5	
	44,162		6,580	100	

NDITIONS, NONIRRIGATION SEASON

LD /ha	PRODUCTION Kg	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth.$		TOTAL INCOME Eth.$	INCREMENTAL INCOME Eth.$
-	—	—	$ —		$ 960	$ 960
180	35,400	35,400	3,604		8,452	8,452
975	24,375	24,375	2,413		2,413	2,413
-	—	—	—		8,165	8,165
950	9,500	9,500	1,569		4,510	4,510
-	—	—	—		1,057	1,057
700	7,000	7,000	1,242		2,280	2,280
—	—	—	—		5,324	5,324
—	—	—	—		4,608	4,608
—	—	—	—		7,768	7,768
—	—	—	—		2,573	2,573
—	—	—	—		11,460	11,460
			8,828		59,570	59,570
			—			
			8,828		59,570	59,570
			—		—	—
			8,828		59,570	59,570

CROP PATTERN	CONDITIONS BEFORE PROJECT				
	CROP 1/ DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	PRICE RECEIVED PER 100 Kg Eth.$	INCOME Eth.$
Buckwheat	-			$ 9.60	
Corn	-			10.18	
Millet (dagussa)	-			9.90	
Sorghum	-			13.70	
Haricot beans	-			16.52	
Flaxseed	-			21.14	
Mustard	-			17.75	
Castor beans	-			26.62	
Sunflower	-			25.60	
Coffee	-			161.84	
Peppers	-			55.93	
Tobacco (Oriental)	-			114.60	
Subtotal, Crops	-				
Fallow	-				
Subtotal, Cultivated area	-				
Noncultivated irrigable land	15,000				
Total area	15,000				

1/ This project area is uninhabited at present.

TABLE VI-5 . Summary of Farm Income for Estimating Benefits by Use of the Gross Crop Inco
Finchaa Project, Ethiopia, on a Full Project, 15,000-hectare Basis

FUTURE CONDITIONS, IRRIGATION SEASON						
CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	SHIPMENT TO CENTRAL MARKET Kg	VALUE OF SHIPMENT TO CENTRAL MARKET Eth.$	LOCAL CONSUMPTION Kg	VALUE OF LOCA CONSUMPTIOI Eth.$
750	2,000	1,500,000	1,125,000	$ 108,000	375,000	$ 36,000
2,250	3,175	7,143,750	6,272,750	638,565	871,000	88,669
-	-	-	-	-	-	-
3,000	2,980	8,940,000	5,415,000	741,855	3,525,000	482,925
1,500	1,780	2,670,000	2,670,000	441,084	-	-
750	1,000	750,000	750,000	158,550	-	-
750	1,170	877,500	877,500	155,756	-	-
1,500	2,000	3,000,000	3,000,000	798,600	-	-
1,500	1,800	2,700,000	2,700,000	691,200	-	-
750	960	720,000	615,000	995,316	105,000	169,932
750	920	690,000	315,000	176,179	375,000	209,937
750	2,000	1,500,000	1,500,000	1,719,000	-	-
14,250				6,624,105		987,463
-				-		-
14,250				6,624,105		987,463
750				-		-
15,000				6,624,105		987,463

Method,

FUTURE CONDITIONS, NONIRRIGATION SEASON				
CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth.$
-	-	-	-	-
4,500	1,180	5,310,000	5,310,000	540,558
3,750	975	3,656,250	3,656,250	361,969
-	-	-	-	-
1,500	950	1,425,000	1,425,000	235,410
-	-	-	-	-
1,500	700	1,050,000	1,050,000	186,375
-	-	-	-	-
-	-	-	-	-
750	-	-	-	-
-	-	-	-	-
-	-	-	-	-
12,000				1,324,312
2,250				-
14,250				1,324,312
750				-
15,000				1,324,312

NS, NONIRRIGATION SEASON					
RODUCTION Kg	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth.$		TOTAL INCOME Eth.$	INCREMENTAL INCOME Eth.$
-	-	-		$ 144,000	$ 144,000
5,310,000	5,310,000	540,558		1,267,792	1,267,792
3,656,250	3,656,250	361,969		361,969	361,969
-	-	-		1,224,780	1,224,780
1,425,000	1,425,000	235,410		676,494	676,494
-	-	-		158,550	158,550
1,050,000	1,050,000	186,375		342,131	342,131
-	-	-		798,600	798,600
-	-	-		691,200	691,200
-	-	-		1,165,248	1,165,248
-	-	-		386,116	386,116
-	-	-		1,719,000	1,719,000
		1,324,312		8,935,880	8,935,880
		-		-	-
		1,324,312		8,935,880	8,935,880
		-		-	-
		1,324,312		8,935,880	8,935,880

Minor amounts of meat and animal products might be produced locally by project residents, and garden plots around the homes should be encouraged. Furthermore, tests conducted on the experimental farm might determine that certain vegetables and fruits are suitable for eventual inclusion in the cropping pattern.

Certain crops proposed for the project, including castor beans, coffee, and tobacco are either nonedible or have a very low caloric value. All production of these crops, although not expressible in nutritional terms, must nevertheless be considered net additions to the agricultural economy.

Table VI-6 shows the production and consumption of calories on the Finchaa Project.

Alternative Crops

In the future, as the industrial economy of the country develops and the cities enlarge, cash crops will be in greater demand. The Finchaa Project should gradually turn to those crops which it is best able to produce, and should gradually eliminate those less adaptable and those grown primarily for subsistence. Other project areas, for example, may eventually produce all of the sorghum or haricot beans now projected for Finchaa, leaving a greater proportion of the cropland available for such high-value crops as peppers, coffee, or tobacco. In the future the project area may assume a stronger cash position, shipping the large bulk of its production to the cash markets, and purchasing most of its food requirements from other areas farther from the central market or less climatically adapted to production of specialty crops.

There are many alternative crops that may replace some of the crops suggested. Some of these, however, are less adapted to the Finchaa area, while others might not be as financially remunerative or less acceptable in the Ethiopian diet. Still others may have export possibilities but are unknown today in Ethiopia. Time and experience may allow some of these crops a place within the cropping pattern.

Grains. Four grains are projected for the Finchaa area; buckwheat, corn, sorghum, and African millet or dagussa. The grains are the largest group of crops projected, and are intended partly for production of food for the project population, and partly as surplus to ship off the project. Grains may diminish in importance as the economy grows and demand for coffee, peppers, castor beans, and tobacco increases.

TABLE VI-6 - PRODUCTION AND DISPOSITION OF CROPS, EXPRESSED IN TERMS OF CALORIES

Irrigation Season

Crop 1/	Calories per kg.	Production, kg.	Production, Calories	Shipment to Central Market, Calories	Local Consumption, Calories
Buckwheat	2,757	2,625,000	7,237,125,000	6,203,250,000	1,033,875,000
Corn	3,500	7,143,750	25,003,125,000	21,954,625,000	3,048,500,000
Sorghum	3,620	8,940,000	32,362,800,000	19,602,300,000	12,760,500,000
Haricot beans	3,430	2,670,000	9,158,100,000	9,158,100,000	-
Flaxseed	4,720	750,000	3,540,000,000	3,540,000,000	-
Mustard	4,600	877,500	4,036,500,000	4,036,500,000	-
Sunflower	5,120	3,705,000	18,969,600,000	18,969,600,000	-
Peppers	3,170	690,000	2,187,300,000	998,550,000	1,188,750,000
Subtotal, irrigation season			102,494,550,000	84,462,925,000	18,031,625,000

Nonirrigation Season

Crop	Calories per kg.	Production, kg.	Production, Calories	Shipment to Central Market, Calories	Local Consumption, Calories
Corn	3,500	5,310,000	18,585,000,000	-	18,585,000,000
Millet	3,300	3,656,250	12,065,625,000	-	12,065,625,000
Haricot beans	3,430	1,425,000	4,887,750,000	-	4,887,750,000
Mustard	4,600	1,050,000	4,830,000,000	-	4,830,000,000
Subtotal, nonirrigation season			40,368,375,000	-	40,368,375,000
Total, irrigation plus nonirrigation season			142,862,925,000	84,462,925,000	58,400,000,000

1/ Excluding castor beans, coffee, and tobacco.

The grains selected are adapted to the Finchaa climate, are well accepted in Ethiopian homes and markets, and form an important part of the diet. Only one new cereal, buckwheat, is included. Alternatives include rice, buckwheat, and baltuk.

Rice (Oryza sativa) can be grown up to 1500 meters on irrigated lands, and will thrive on tight, puddled soils. Rice, however, is unknown in the Ethiopian diet, except for some foreign and Moslem groups. Furthermore, rice grown in Blue Nile areas cannot compete on the present world market with Asian, European, and American rice.

Baltuk or pearl millet (Pennesetum glaucum) is a minor indigenous Ethiopian crop. It will grow in the Finchaa area, but does not appear to enjoy as much favor as other grains. Among lowland populations it is more popular.

Cool weather cereals which will not return their best yields in this area include teff (Eragrostis abyssinrea), barley (Horedeum spp.), oats (Avena sativa), wheat (Triticum spp.), and rye (Secale cereale). Oats and rye would encounter severe marketing difficulties as well.

Pulses. The only pulse included in the cropping pattern is the haricot, navy, or field bean (Phaseolus vulgaris). If this crop should not prove successful in the Finchaa or if the area under pulses is expanded, horse beans, field peas, or mung beans might be considered.

Horse beans (Faba vulgaris) are a well-liked indigenous crop, with a good export market. They do not command as high a price as haricot beans, however.

Field peas (Pisum sativum) are an important indigenous food crop, but may be at the borderline of their tolerance for heat in the Finchaa. If planted immediately in the fall, they may mature a crop without loss caused by warm weather. Their most promising use may be as a nonirrigated crop in the rainy season.

Mung beans (Phaseolus aureus) are more tolerant of heat. This crop is not known in Ethiopia today, although efforts to introduce them have been made. Mung beans can be used directly for food or crushed for oil.

Other indigenous pulses, including chick peas (Cicer arietinum); fenugreek (Trigonella foenum-graecum); and lentils (Lens esculenta) probably would find the Finchaa valley too warm.

Oilseeds. The cropping pattern lists flaxseed (Linum usitatissimum), mustard (Brassica nigra), sunflower (Helianthus annus), and castor beans (Ricinis communis). Flaxseed and mustard are basic oilseeds in Ethiopia, widely grown and consumed. Sunflower is not a common source of vegetable oil in the Ethiopian diet, but an oil-bearing plant intended primarily for export, with possibilities for gradual introduction into the local diet. Castor beans, although presumed indigenous to Ethiopia, are not edible and find little use in the country. They are intended entirely for export, and for such specialized industries as may develop in Ethiopia in the future. Among future possibilities rape, sesame, safflower, soybeans, and peanuts are the most promising for the Finchaa area.

Rape or rapeseed (Brassica napus) is produced at scattered locations in the Ethiopian highlands. The crushed seeds yield an edible oil, and the young leaves are consumed as a minor leafy vegetable. Rape may also be used for pasture and for poultry green feed. Since rape prefers a cool climate, the Finchaa valley may be somewhat low and warm for optimum development, but a crop planted in the fall may yield well.

Sesame (Sesamum indicum) is grown in the Blue Nile Basin as a minor oilseed. It is considered a promising crop for warm temperate regions. Sesame oil is used for cooking and soap, sesame oilmeal for poultry and livestock feed, and sesame seeds are sprinkled on breads and pastries. The crop may have strong export possibilities.

Safflower or saffron (Carthamus tinctorius), not to be confused with wars, or bastard saffron (Crocus sativus), is a minor indigenous oilseed grown in the highlands for a cooking oil and soap. On the world market, it is a drying industrial oil for varnishes and soap. Formerly it was best known as a source for dye.

Soybeans (Glycine hispida) are cultivated on a very minor scale in Ethiopia at the present time. The crop is adaptable to Finchaa area climatic conditions. Soybeans may be used for meal, oil, as green beans, and as dry beans. Both the meal and the oil have a great many edible and nonedible uses.

Peanuts or groundnuts (Arachis hypogaea) are botanically a pulse but are regarded as an oil seed because of the wide variety of products made from the oil. The climate of the Finchaa is probably quite suitable for peanut cultivation, but peanuts should be grown only on the loose, well drained soils if the tubers are to set properly.

Noog or nigerseed (Guizota abyssinica) is the most important indigenous Ethiopian oilseed. The Finchaa area probably lies too low for commercial production of this crop, however. Another problem is the tendency to shattering of the seed, since this crop has not been improved for machine harvest.

Sugar crops. Sugar cane (Saccharum officinarium) can probably be grown well in the Finchaa area. It will thrive in a warm climate under irrigation, particularly where several dry months occur during ripening. It will grow on a variety of soils, including heavy clays and loams. Furthermore, sugar is accepted in the Ethiopian diet and the consumption is increasing.

Sugar cane, however, is excluded from the cropping projection of the Finchaa and other Blue Nile project areas. At present the entire commercial production is grown by a Dutch plantation at Wonji, near Addis Ababa. This plantation supplies domestic requirements and manufactures sugar candy to create an even larger market. A monopoly, awarded to this firm, prohibits competitive commercial plantings a certain number of kilometers around Wonji.

Sugar beets (Beta altissima) are not strictly adapted to the Finchaa area, because of particular heat and water requirements. If a sugar crop is desired after the project has become established, the respective merits of cane and beets should be re-examined.

Vegetables. Vegetables are not greatly enjoyed in Ethiopia. Vegetable consumption by most people is quite low, although certain varieties are cooked in "wat", others are eaten raw, and still others are liked by certain urban groups. Only the red pepper, which is as much a spice as a vegetable, is consumed to a large extent.

Other known vegetables include onions, potatoes, cabbage, pumpkins, and squash. A coarse member of the cole group, locally called "gomen", and some mustard, rape, and cress leaves are eaten as salad, and small quantities of wild asparagus and mushrooms are gathered. But over-all vegetable consumption, as measured by groups interested in Ethiopian nutritional patterns, is very low. 1/ A serious factor affecting the choice of vegetables, in addition to adaptability and yield, is, therefore, the degree of acceptance in the marketplace.

1/ The Ethiopia Nutrition Survey mentions that vegetables, exclusive of pulses and peppers, supply only 2.6 percent of the daily caloric intake. The Planning Board claims 3.8 percent, and the Limu Survey only 0.7 percent.

Many vegetables are culturally adapted to the Finchaa area because the valley has a mild climate and irrigation water will be supplied. The project management might decide, once the operations are established and a certain amount of financial loss is allowable, to try small plantings on the experimental farm. If this were successful and the crops were marketable, then the farmers might consider their propagation. However, garden plantings by private farmers should be encouraged to supplement the diet.

Initial harvest of "exotic" vegetables (those little known in Ethiopia but well accepted elsewhere) could be sold in the foreign markets in Addis Ababa and elsewhere. Gradually these may become accepted throughout the population, a circumstance that has come about in the case of such crops as lettuce, carrots, cauliflower, and fresh snap beans.

Soil conditions are important when vegetables are grown. Most varieties require a well-drained soil, and will yield poorly on a tight clay. The Finchaa area latosols, with good drainage and low plasticity, are suitable for many types. Future vegetable production might become important here, assuming acceptance by the Ethiopian population.

The growing season for most vegetables is so short that there are actually two seasons per irrigation season. This is very significant in regard to heat tolerances. Fall months are generally the cooler and spring months warmer. Therefore, the short-season cool weather crops could be sown at the start of the irrigation season; the heat-loving short-season crops in January and February.

Cool season possibilities:

Root crops: Beet (Beta vulgaris), carrot (Daucus carota), leek (Allium porrum), radish (Raphanus sativus), rutabaga (Brassica napobrassica), and turnip (Brassica napa).

Salad crops: Endive and escarole (Cichorium endiva), fennel (Foeniculum vulgare), garden cress (Lepidium sativum), lettuce (Lactuca sativa), parsley (Petroselinum hortense), spinach (Spinacea oleracea), Swiss chard (Beta vulgaris, var. cicla), upland cress (Barbarea vulgaris), and water cress (Nasturium aquaticum).

Pulses: Garden peas (Pisum sativum, var. macrocarpon).

Cole crops: Broccoli (Brassica oleracea, var. Italica), cabbage (B. oleracea, var. capitata), cauliflower (B. oleracea, var. botrytus), Chinese cabbage (B. pekinesis), collards (B. oleracea, var. acephala), and kale (B. caulorapa).

Warm season possibilities:

Salad crops: Celery (Apium graveolens).

Pulses: Lima beans (Phaseolus limensis), and snap beans (Phaseolus vulgaris, var. humilus).

Solanaceous crops: Eggplant (Solanum melogena), sweet peppers (Capsicum frutensens, var. grossum), and tomato (Lycopersicon esculentum).

Other: Cucumbers and melons (Cucumis species), okra (Hibiscus esculentus), pumpkin and squash (Cucurbita species), and sweet corn (Zea mays, var. saccharata).

Crops that require excessive time for propagation or impose excessively high costs of production include artichoke, asparagus, horseradish, mushrooms, rhubarb, sweet potatoes, and watermelons. Onions and potatoes, now grown in Ethiopia, should not be considered for the Finchaa. Onions (Allium cepa) are adversely affected by temperatures in excess of 21° C. (70° F.). Potatoes (Solanum tuberosum) will not set tubers above 29° C. (84° F.). Since higher temperatures are expected, neither of these crops is suitable.

Fruit, Berries, and Nuts. Fruit production in the Finchaa area is subject to greater restrictions than vegetable growing. The per capita consumption of fruit is even lower than vegetables, and is largely confined to foreign groups, upper income urban Ethiopians, and certain lowland groups. Transportation difficulties, perishability of the products, and a lack of processing facilities would discourage a large export market. Fruit production is generally a long-term project, requiring years before crops can be harvested. And the Finchaa area has certain climatic features which render it unsuitable for many popular types of fruit.

Fruit. Climate of the Finchaa valley, and actually of much of the Blue Nile Basin, is a severe limiting feature. The lack of a pronounced winter season precludes all possibility of temperate trees which require dormancy or rest, and aggregate of heat units is insufficient for maturation of many tropical crops, which would tend to reduce yields. The best solutions are the subtropical plants which will fruit without dormancy or will enter dormancy without freezing temperatures. Furthermore, the effect of the long summer rainy season on subtropical crops should be considered, particularly on imported varieties.

For this reason, propagation of such popular temperate zone fruits as apples, cherries, pears, nectarines, and peaches should not be attempted. Also no plantings of bananas, papaya, dates, breadfruit, mango, pineapple, or other tropical crops should be made. Although bananas are seen even higher in elevation than the Finchaa valley, production is uncertain and yields are low. Furthermore, some subtropical crops which will tolerate some cool weather, including citrus and olives, probably would not yield well here.

Nevertheless, a few fruit crops may be successfully grown in the Finchaa area. Some are known in Ethiopia, but most are not. The European grape (Vitus vinifera) is one of these. Grapes are one of the few fruits consumed in Ethiopia in a variety of forms. The crucial factor concerning vitriculture is the cold and heat requirement. Some varieties of V. vinifera will undergo rest in the absence of freezing temperatures, and still mature a crop. Therefore selection of the proper variety is paramount. Grapes are now being grown in scattered Blue Nile areas.

The fig (Ficus carica) will tolerate a cool dormancy period, so should not suffer from lack of low temperatures during its annual cycle. However, fruiting is retarded both by cool nights and by temperatures below 38° C. (100° F.) in certain seasons.

The litchee or lychee (Litchee chinensis) has been grown in China for centuries along rice paddies and canals to hold the banks in place. The tree is perfectly adapted to tropical uplands. It will neither fruit in hot humid climates nor tolerate heavy frost. It may also be grown as an orchard tree. The edible portion is a fruit which when dried is called "litchee nut."

Litchee requires a perfectly drained soil, and will produce a full crop in seven or eight years. Since the fruit is unknown in Ethiopia, and in view of the long period needed to produce the crop, it may be planted as an ornament or near the project waterways rather than as a commercial crop. If so, it should be evaluated against the eucalyptus, which will produce firewood and make a more rapid growth and which can also be planted along waterways.

The longan or Dragon's eye (Euphoria longan) is a hardy relative of the litchee. This tree may be best utilized in the higher Blue Nile project elevations, where frost is more probable. The fruit is similar to the litchee and the tree has ornamental possibilities, as well as being suitable for planting along waterways.

The loquat (Eriobotrya japonica) is a member of the rose family that is adapted to tropical highlands. It thrives in cool

subtropical climates, preferably above 1000 meters, where there is freedom from hard frost and extreme heat. It requires a well-drained clay for best growth, and the fruits are eaten fresh or preserved.

The cherimoya and the ilama (Anona spp.) are related to the genus soursop, the custard apple, and the sugar apple. These last three are tender, but the cherimoya and ilama thrive in tropical uplands on perfectly drained soils. The fruits may be eaten fresh, or crushed and mixed with liquids as a sherbet.

The Japanese persimmon or kaki (Diospyros kaki) will thrive above 1000 meters in the tropics. It must have a well-drained soil. The fruits are consumed fresh or dry.

None of the important citrus fruits (Citrus spp.), including the orange, grapefruit, lime, lemon, and citron, is suitable for commercial propagation in the Ethiopian highlands. Fruiting is retarded by cool temperatures, and the trees prefer a sandy soil with good drainage. However, there are some minor species that have somewhat different requirements. The mandarin or tangerine (Citrus reticulata) will grow up to 1500 meters in the tropics. The kumquat (Fortunella species) and the trifoliate orange (Poncirus trifoliate) will grow even higher. However, the Blue Nile Basin does not show promise as a citrus growing area, and citrus production probably should be confined to certain lowland areas of Ethiopia.

The tree tomato (Solanum betaceum) is a perennial tree related to the common or vine tomato, which produces a tomato-like fruit. It is a hardy plant that requires cool nights, and should grow well in highland tropical areas, such as the Finchaa. Since there already has been some small degree of acceptance of tomatoes in Ethiopia, this crop may be of use. The naranjilla (Solanum quitonse) is another relative of the tomato that is found in the tropical highlands of South America. The fruits may be consumed fresh or used for juice or preserves.

Berries. In view of the very small consumption of berries of any type in Ethiopia, and the difficulties of growing the common varieties in a subtropical climate, berry propagation in the Finchaa valley should not be considered now. Furthermore, berry crops are noted for perishability, and require either immediate transportation to market, or local preserving facilities.

Strawberries (Fragaria chiloensis) require either freezing temperatures during the rest period, or high daytime temperatures if a variety which does not require rest is chosen. Length of day

is important for heavy yields, and nearby marketing or processing facilities are essential. Although crops can be produced in the Blue Nile Basin, yields are not high, and markets are not extensively developed.

Bramble berries, and the Youngberry, Boysenberry, and Loganberry, all Rubus species, which include the red, black, and purple raspberry, the blackberry, and the dewberry, require a dormancy period with cool temperatures.

The currant (Ribis spp.), gooseberry (Ribis uva-crisca), blueberry (Vaccinium spp.), and cranberry (Vaccinium spp.) are nonbramble berries which require much more rigorous winter temperatures than the Finchaa area provides.

Nuts. Few species of nuts are adapted to commercial planting in highland Ethiopia. Many of the major species of tropical origin do not thrive in subtropical or temperate areas. They require high daytime temperatures, warm nights, and absolute freedom from cold weather or frost. Cool nighttime temperatures during the budding and blossoming period are injurious to the reproductive parts of the plant. The temperate zone nuts, on the other hand, require a dormancy period, which would not be provided by the Finchaa area. Furthermore, the strangeness of these crops would be a marketing handicap, and the years required to produce a crop an additional disadvantage.

The Ecuador, Bolivia, and Colombia walnuts (Juglans honorei, J. boliviana, and J. colombiensis), found in highland South America, are slight possibilities. The mu-yu-shu, or mu-yu-oil nut, a relative to the tung nut, is adapted to the tropical highlands. The oil resembles tung oil and is used as a dryer for paints and varnishes.

Probably no nut plantings should be considered for the Finchaa area. However, the project area may be examined for indigenous nuts, as well as for other useful plants.

Fibers. No fiber crops are projected for the Finchaa area. Flaxseed, used for fiber elsewhere, is included only for production of seed. Experiments with fiber flax in 1951 and 1952 indicated that it could be grown in the Ethiopian highlands, but this was never implemented. Commercial equipment for reducing the flax to fiber is not available in the country. Flax is a variety of L. usitatissimum. The stems are straighter and longer, with fewer branches. Only small amounts of seed, of low oil content, are borne.

155

Ramie (Boehmeria nivea) is a subtropical fiber presently found in scattered sections of the Blue Nile highlands. New Zealand flax (Phormium tenax) is a hardy relative of sisal that can be grown only in the subtropics. Hemp, or true hemp (cannabus sativa), is a temperate zone plant that produces the raw material for fiber, but also is the source of the drug marijuana, hashish, or bhang. Hemp might be avoided for this reason. Cabuya (Furcraea cabuya), another hardy relative of sisal, is a Central American plant grown up to 1800 meters.

Many other fibers grown elsewhere require tropical conditions for best growth. Among these are Manila hemp (Musa textiles); dum palm (Phytelephas macrocarpa), found in lowland Eritrea; jute (Corchoris species); kapok (Eriodendron anfractuosum); kenaf (Hibiscus species); sanseviera or bowstring hemp (Sansevieria species); Yucatan sisal or henequen (Agave fourcroydes); and sisal (Agave sisalana). Sisal, however, appears to have a certain tolerance for cooler climates, since it is cultivated in Kenya at 1500 meters.

Cotton (Gossypium species), the major world vegetable fiber, prefers an elevation in Ethiopia not greater than 1000 meters. Although perennial forms may be seen much higher, yields are extremely low by commercial standards, maturity is delayed by cool weather, and losses by disease and insects are increased by late maturity. At present, cotton growing schemes are being conducted in several lowland Ethiopian areas.

False banana (Musa ensete) deserves special mention. It is an indigenous relative of the true banana, and has been cultivated in Ethiopia for centuries. The greatest use is the starchy pseudostem as a dietary staple, and the pseudostem and leaves yield a fibrous strand. At one time false banana was an important highland crop, but with the shift of population the plant has been pushed farther south. Growth is better in the lower, warmer areas.

Stimulants and Spices. Coffee, tobacco, and hot peppers are projected for the Finchaa area. However, there are many possible alternatives.

Khat or chat (Catha edulis) is a perennial indigenous shrub cultivated in many parts of Ethiopia. The leaves and young twigs are chewed for a stimulating effect. Possible detrimental effects are suffered by the user, and khat is a habit-forming narcotic. Several neighboring countries have banned the import of Ethiopian khat, and the khat trade is frowned upon by the World Health Organization. Therefore, no khat is projected for the Finchaa or any other Blue Nile project.

Tea (Thea sinensis) is a subtropical shrub with doubtful application for the Finchaa valley. The long cloudy summer, the spring rains, and nighttime temperatures below 13° C. (55° F.) would reduce yields. Tea also requires a processing plant nearby to receive the leaves, or else a more distant plant with air service to the project.

Gesho or buckthorn (Rhammus prinoides), a substitute for hops, is used in brewing beer. It is a small perennial shrub found wild in the Ethiopian highlands.

Peppers are the only spice included in the cropping projection. Many spices, however, are consumed in the Ethiopian diet, and some of these might be included if more data were available regarding their production, growth, and yields. However, the scantiness of information, the small scale, and the simple methods of cultivation make the response of any given spice to modern, irrigated farming impossible to predict. Therefore, spices now important in the diet should be tested on the project experimental farm before field plantings are considered. Important Ethiopian spices include anise (Pimpinelle anisum); black cumen (Nigella sativa), caraway (Carum carvi), cardamon (Elettaria cardamonium), coriander (Coriandrum sativum), dill (Anethum graveolens), lemongrass (Andropogon citratus), marjoram or oregano (Origanum marjorana), and tumeric (Curcuma longa).

Ethiopia uses a great variety of spices, including many not mentioned above, but her production does not suffice for her needs. Net spice imports have increased yearly, and in 1960/61 were Eth$609,000. Therefore the marketability of accepted spices is assured, in contrast to future plantings of fruit, vegetables, or nuts.

Care must be taken to insure that the spices tested on the experimental farm are adapted to subtropical conditions. Spices adapted only to tropical conditions include black and white pepper, cloves, ginger, nutmeg or mace, and pimento.

Medicinal and Essential Oil Plants. A large number of potentially valuable plants whose oily exudations or secretions are used for medicine, perfumes, flavoring, or lubrication are found in Ethiopia, either cultivated or in the natural state. Here again the cultivation is small and data are lacking. These plants are utilized in their crude state, but the finished products of many are imported into Ethiopia in more expensive, compounded forms. Accordingly some may deserve testing, for consideration in future cropping patterns.

The best known medicinal plants found in Ethiopia today are foxglove (Digitalis species), the source of digitalis; saffron (Crocus sativus); senna (Cassia species); thorn apple (Datura stratomium); and wild rose or hip (Rosa canina). A drug not grown in Ethiopia but an important cash crop in highland Kenya is pyrethum (Chrysanthenum species).

Essential oil plants found in highland Ethiopia, many of which have pharmaceutical, food processing, or industrial usage include peppermint, spearmint, and pennyroyal (Mentha piperita, M. crispa, and M. virdiris); and thyme (Thymus species). The oil of the Ethiopian eucalyptus (Eucalyptus globulus) is used abroad but is not extracted in Ethiopia.

Many common Ethiopian plants produce useful oils in their leaves, stems, or blossoms, including the carnation, daffodil, elder, geranium, heliotrope, honeysuckle, iris, lavender, lilac, lily, narcissus, patchouli, rosemary, sweet pea, tuberose, violet, and wall flower. Most of these are common temperate zone flowers.

Before commercial planting of essential oil plants is made on the Finchaa or other projects, the establishment of a rendering or extracting plant must be considered, or else export possibilities studied.

Firewood. A persistent problem in Ethiopia has always been the procurement of an adequate supply of firewood. The eucalyptus, since its introduction, has been a partial solution; where it is planted the available supply of firewood is always increased. The Finchaa Project will face the problem of fuel for cooking and heating. If electric power is not suitable for domestic use in the Finchaa area, and since fossil fuels are expensive in Ethiopia, the eucalyptus may be the answer here, too.

No land is specifically allotted to coppices of trees. However, five percent of the irrigable land is projected for the farm house and lot, farm roads, and ditches. A portion of this might be planted in eucalyptus, to supply fuel after the wood and vegetative debris cleared from new lands has been exhausted. Several years are required before firewood can be harvested economically from coppices.

Another possibility is the planting of trees along portions of the irrigation canals. Species mentioned earlier include the litchee, longan, and loquat. Other possibilities, either along the waterways or in coppices, are the newly introduced pines, cypresses, and Australian acacia. This question should be considered in detail in the final Finchaa study, in cooperation with the Ethiopian Forestry Association.

Livestock

The integration of livestock with irrigated farming in the Finchaa Project area poses a set of problems that are probably best avoided in the beginning years of project operations. The inclusion of livestock means careful attention to breeding programs, disease control and eradication, maintenance of grain and forage supplies, and development of markets for profitable turnover of livestock and products. These problems are not always solved successfully under conditions where quality stock is produced, markets are established, heavy per capita meat consumption exists, adequate transportation facilities are available, fodder reserves are ample, and where diseases and pests have been brought under control. But in Ethiopia, major problems exist in each of these phases of the livestock production and marketing cycle. Moreover, enormous areas outside the Blue Nile Basin could be developed for livestock production on a nonirrigated basis. Portions of the Awash valley and of the vast semiarid area southeast or south of Addis Ababa can produce livestock on an extensive basis. Some of these areas are served by rail transport both to Addis Ababa and to the port of Djibouti on the Red Sea. Therefore consideration of livestock has been excluded on a commercial basis from the Finchaa and the other Blue Nile irrigation projects, for the immediate present.

This need not mean that livestock must be entirely absent from the project area. The Ethiopian farmer is accustomed to having a few head of livestock on hand, and he counts his wealth partly in animals. It is recommended that the project population be allowed to keep some livestock as personal possessions, partly as a concession to their conservative outlook, and partly because there will always be some waste areas, such as nonarable land, land along fence rows, irrigation ditches and canals, and in villages, where cattle, sheep, or goats can be grazed at no cost to the project. Furthermore, the milk and meat produced would be nutritious supplements to the basic foodstuffs the project will raise. The number of head must be supervised to prevent overgrazing of the available pasturage. Rules concerning ownership per family should be formulated in advance of project operations.

Land Settlement

At the present moment, the Finchaa valley is uninhabited. With the commencement of project operations as much as 640 hectares will be immediately developed, and population settled on this land. This will require about 608 farmers and workers, excluding managerial and service personnel, and excluding the irrigable land required for farm houses, roads, and woodlots. Applying the average family size of 4.7 members, approximately 2,800 people can move into the Finchaa Project area and find land and work.

Under ultimate development, the entire 15,000 hectares of irrigable land should be occupied. This will offer settlement opportunities to over 65,000 farm people (see SECTION IX), plus others required for management, operation and maintenance, and extension. In addition, many service workers will be drawn into the area.

AMARTI-NESHE PROJECT

The land classification and agricultural economics of the Amarti-Neshe Project are essentially the same as the Finchaa Project. The Amarti-Neshe Project is smaller, however, so crop production will be less. Therefore only the summary sheets, which reflect the differences in size, are shown separately. The discussion of agricultural conditions before project development, agricultural conditions after agricultural development, and land settlement would be covered under the Finchaa Project.

Tables VI-7 and VI-8 are designed to show the agriculture of the Amarti-Neshe Project in terms of crop production and of gross income to be realized by the project from the sale of crops. Table VI-7 shows the production on the basis of 100 hectares, and Table VI-8 on a full project, 8,490-hectare basis. These tables are identical to the Finchaa Project summary sheets in all but one respect. Total gross crop income for the Finchaa is $8,932,130; for the Amarti-Neshe it is $5,061,975.

The consumption of food will follow a similar pattern for the Amarti-Neshe as the Finchaa Project. Total yearly production of calories will be approximately 81,000,000,000; of this, 33,000,000,000 will be consumed on the project and the remainder sold.

CROP PATTERN	CONDITIONS BEFORE PROJECT				
	CROP 1/ DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	PRICE RECEIVED PER 100 Kg Eth. $	INCOME Eth. $
Buckwheat	-			9.60	
Corn	-			10.18	
Millet (dagussa)	-			9.90	
Sorghum	-			13.70	
Haricot beans	-			16.52	
Flaxseed	-			21.14	
Mustard	-			17.75	
Castor beans	-			26.62	
Sunflower	-			25.60	
Coffee	-			161.84	
Peppers	-			55.93	
Tobacco (Oriental)	-			114.60	
Subtotal, Crops	-				
Fallow	-				
Subtotal, Cultivated area	-				
Noncultivated irrigable land	8,490				
Total area	8,490				

1/ This project area is uninhabited at present.

TABLE VI-7 . Summary of Farm Income for Estimating Benefits by Use of the Gross Crop Inc
Amarti-Neshe Project, Ethiopia, on a Full Project, 8,490-hectare Basis

FUTURE CONDITIONS, IRRIGATION SEASON						
CROP DISTRIBUTION ha	YIELD Kg / ha	PRODUCTION Kg	SHIPMENT TO CENTRAL MARKET Kg	VALUE OF SHIPMENT TO CENTRAL MARKET Eth.$	LOCAL CONSUMPTION Kg	VALUE OF LOC. CONSUMPTIC Eth.$
425	2,000	850,000	636,750	61,130	213,250	20,470
1,275	3,175	4,048,125	3,550,940	361,485	497,185	50,610
-	-	-	-	-	-	-
1,700	2,980	5,066,000	3,070,850	420,705	1,995,150	273,335
850	1,780	1,513,000	1,513,000	249,950	-	-
425	1,000	425,000	425,000	89,845	-	-
425	1,170	497,250	497,250	88,260	-	-
850	2,000	1,700,000	1,700,000	452,540	-	-
850	1,800	1,530,000	1,530,000	391,680	-	-
425	960	408,000	348,090	563,350	59,910	96,960
425	920	391,000	178,290	99,720	212,710	118,970
425	2,000	850,000	850,000	974,100	-	-
8,075				3,752,765		560,345
-				-		-
8,075				3,752,765		560,345
415				-		-
8,490				3,752,765		560,345

e Method,

FUTURE CONDITIONS, NONIRRIGATION SEASON				
CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	LOCAL CONSUMPTION Kg	VALUE OF LOCA CONSUMPTION Eth.$
-	-	-	-	-
2,550	1,180	3,009,000	3,009,000	305,315
2,120	975	2,067,000	2,067,000	204,635
-	-	-	-	-
850	950	807,500	807,500	133,400
-	-	-	-	-
850	700	595,000	595,000	105,610
-	-	-	-	-
-	-	-	-	-
425	-		-	-
-	-	-	-	-
-	-	-	-	-
6,795				748,960
1,280				-
8,070				748,960
415				-
8,490				748,960

	TOTAL INCOME Eth. $	INCREMENTAL INCOME Eth. $
	81,600	81,600
	717,410	717,410
	204,635	204,635
	694,040	694,040
	383,350	383,350
	89,845	89,845
	193,870	193,870
	452,540	452,540
	391,680	391,680
	660,310	660,310
	218,690	218,690
	974,100	974,100
	5,062,070	5,062,070
		-
	5,062,070	5,062,070
		-
	5,062,070	5,062,070

CROP PATTERN	CONDITIONS BEFORE PROJECT				
	CROP 1/ DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	PRICE RECEIVED PER 100 Kg Eth $	INCOME Eth. $
Buckwheat	-			9.60	
Corn	-			10.18	
Millet (dagussa)	-			9.90	
Sorghum	-			13.70	
Haricot beans	-			16.52	
Flaxseed	-			21.14	
Mustard	-			17.75	
Castor beans	-			26.62	
Sunflower	-			25.60	
Coffee	-			161.84	
Peppers	-			55.93	
Tobacco (Oriental)	-			114.60	
Subtotal, Crops	-				
Fallow	-				
Subtotal, Cultivated area	-				
Noncultivated irrigable land	100.0				
Total area	100.0				

1/ This project area is uninhabited at present.

TABLE VI-8 . Summary of Farm Income for Estimating Benefits by Use of the Gross Crop Income Amarti-Neshe Project, Ethiopia, on a 100-hectare Basis

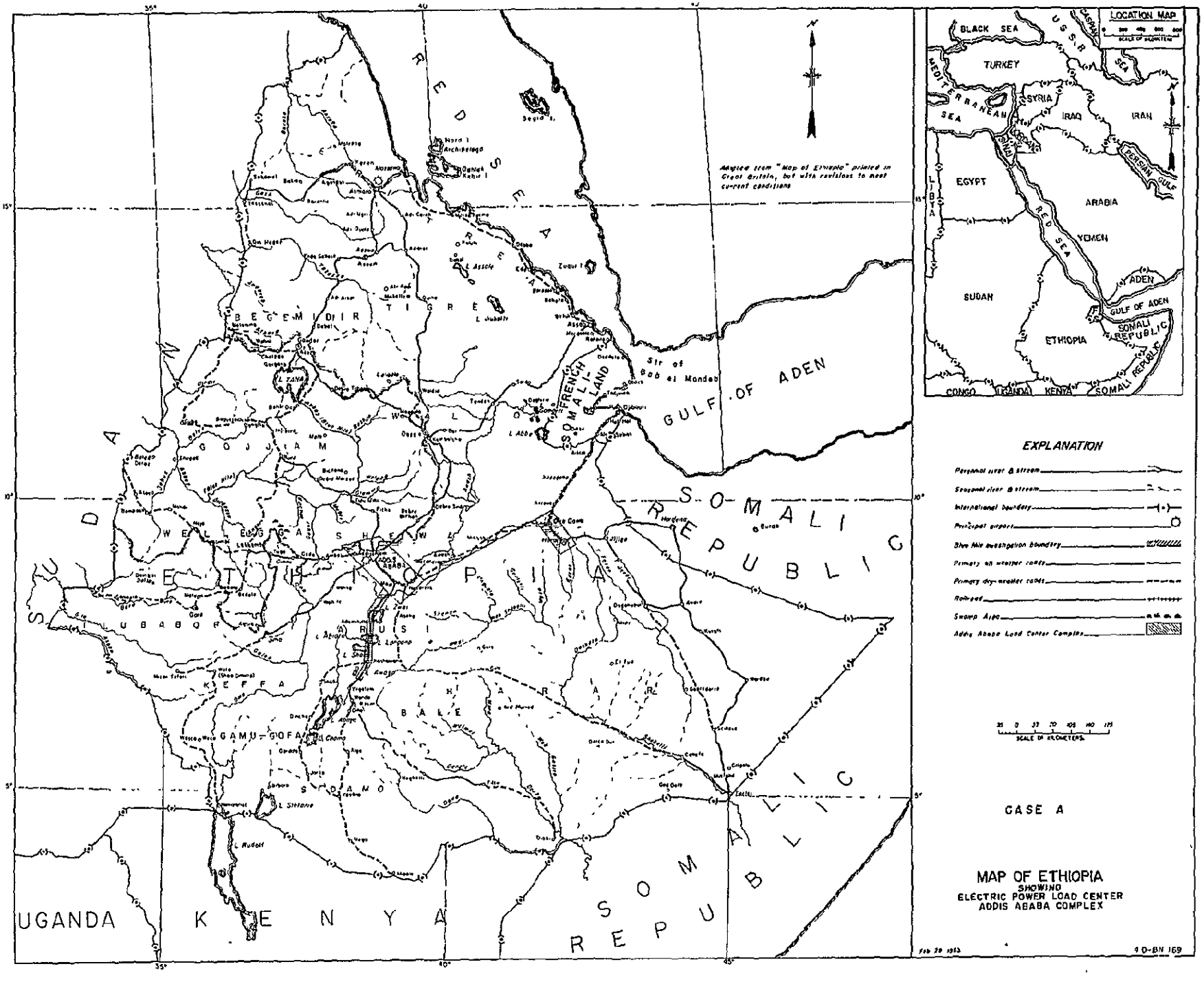
FUTURE CONDITIONS, IRRIGATION SEASON						
CROP DISTRIBUTION ha	YIELD Kg / ha	PRODUCTION Kg	SHIPMENT TO CENTRAL MARKET Kg	VALUE OF SHIPMENT TO CENTRAL MARKET Eth $	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION. Eth. $
5	2,000	10,000	7,500	$ 720	2,500	$ 240
15	3,175	47,625	41,825	4,258	5,800	590
-	-	-	-	-	-	-
20	2,980	59,600	36,100	4,946	23,500	3,219
10	1,780	17,800	17,800	2,941	-	-
5	1,000	5,000	5,000	1,057	-	-
5	1,170	5,850	5,850	1,038	-	-
10	2,000	20,000	20,000	5,324	-	-
10	1,800	18,000	18,000	4,608	-	-
5	960	4,800	4,100	6,635	700	1,133
5	920	4,600	2,100	1,175	2,500	1,398
5	2,000	10,000	10,000	11,460	-	-
95				44,162		6,580
-				-		-
95				44,162		6,580
5				-		-
100				44,162		6,580

Method,

FUTURE CONDITIONS, NONIRRIGATION S			
CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	LOCAL CONSUMPTION Kg
-	-	-	-
30	1,180	35,400	35,400
25	975	24,375	24,375
-	-	-	-
10	950	9,500	9,500
-	-	-	-
10	700	7,000	7,000
-	-	-	-
-	-	-	-
5	-	-	-
-	-	-	-
-	-	-	-
80			
15			
95			
5			
100			

EASON			
VALUE OF LOCAL CONSUMPTION Eth.$		TOTAL INCOME Eth.$	INCREMENTAL INCOME Eth. $
$ -		$ 960	$ 960
3,604		8,452	8,452
2,413		2,413	2,413
-		8,165	8,165
1,569		4,510	4,510
-		1,057	1,057
1,242		2,280	2,280
-		5,324	5,324
-		4,608	4,608
-		7,768	7,768
-		2,573	2,573
-		11,460	11,460
8,828		59,570	59,570
-			
8,828		59,570	59,570
-		-	-
8,828		59,570	59,570
			-

BEST AVAILABLE COPY



Assab is located nearly at sea level, and its precipitation is less than 250 mm per year. It has a hot climate with the average maximum around 28° C and the average minimum probably around 20° C.

Population

A complete census has never been taken of the country. See SECTION II, General Description. A recent census was taken in Addis Ababa and is reflected in Table VII-1.

TABLE VII-1 - ESTIMATED 1961 POPULATION BY CITIES

City or Town	Population
Dessie	35,000
Dire Dawa	40,000
Jima	35,000
Agere Hiywet (Ambo)	10,000
Assab	9,000
Lekkemt	25,000
Addis Ababa	450,000

The Blue Nile River Basin (portions of it lie in seven provinces) was estimated to have a population of about 4,870,000 (see Table VII-2).

TABLE VII-2 - POPULATION FOR BLUE NILE RIVER BASIN BY PROVINCES IN THE BASIN--1961

Province	Population (millions)
Wellegga	1.27
Gojjam	1.18
Shewa	1.09
Wello	0.64
Begemidir	0.45
Ilubabor	0.15
Kefa	0.09
Total	4.87

By comparison, the estimates by provinces for Ethiopia as a whole are shown in Table VII-3.

The size of the present population in the Finchaa and Amarti-Neshe project areas is negligible.

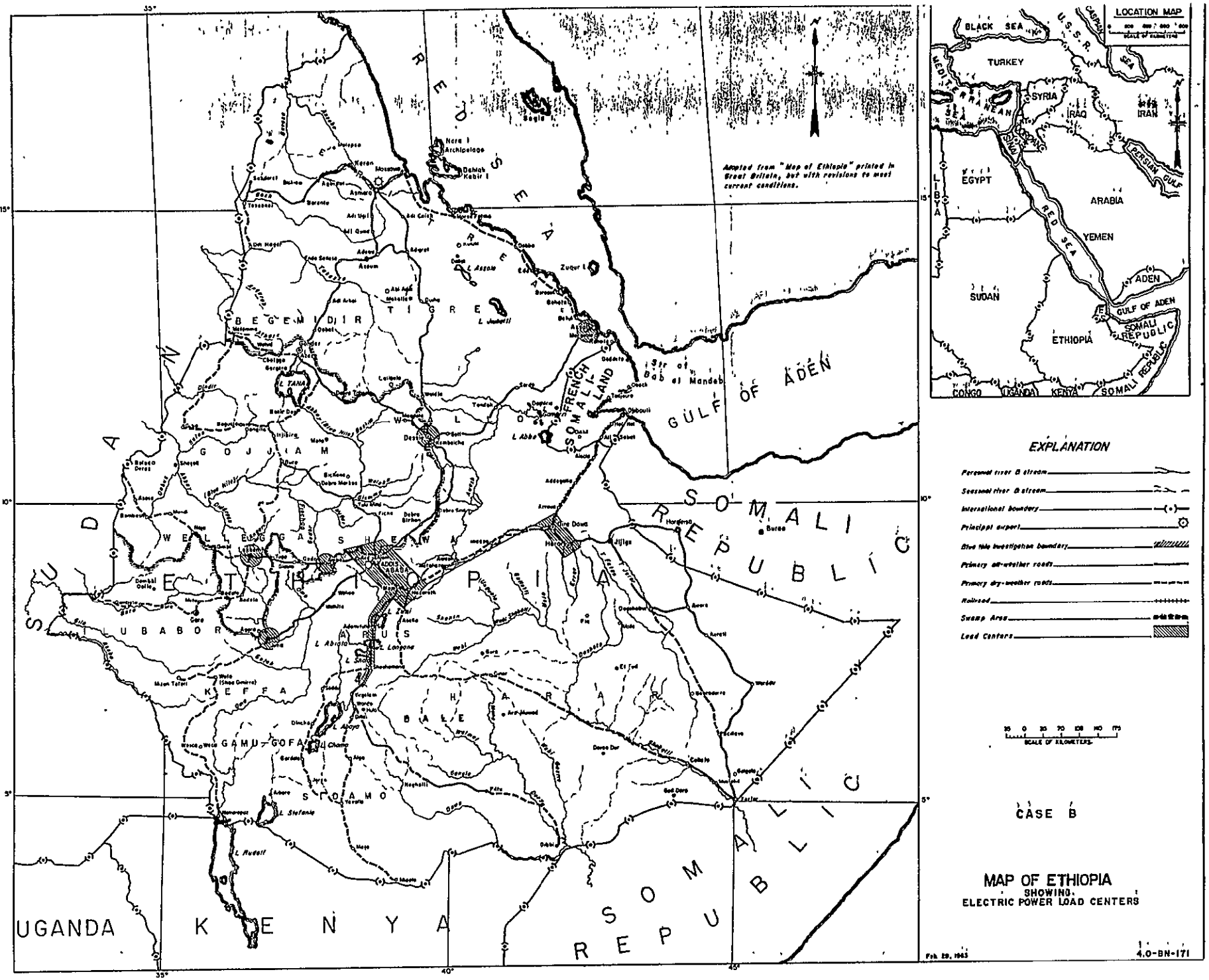
The fastest growing area in the Empire appears to be Addis Ababa, but for the country as a whole, it is believed that the trend in estimated annual population growth may be as shown on Drawing No. 4.0-BN-39.

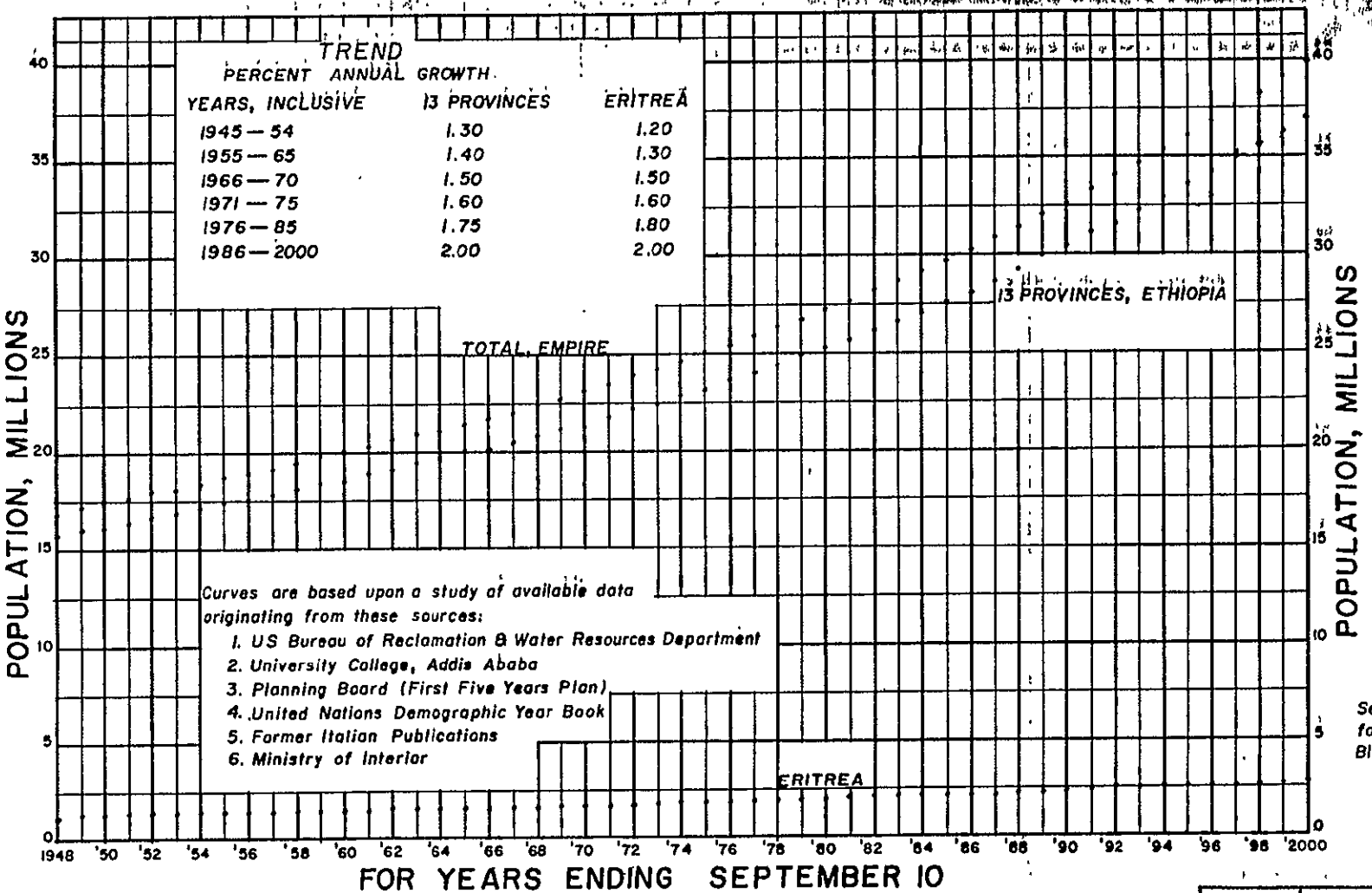
TABLE VII-3 - 1961 POPULATION ESTIMATES--ETHIOPIA

Province	Population (millions)
Tigre	2.59
Wello	2.46
Shewa (w/o Addis Ababa)	2.18
Wellegga	1.73
Sidamo	1.87
Begemidir	1.77
Harar	1.28
Gojjam	1.18
Arusi	.91
Ilubabor	.88
Kefa	.73
Gemu Gofa	.47
Bale	.29
Eritrea	1.46
Provinces	19.80
Addis Ababa	.45
Total Empire	20.25

Occupations of Labor

Some sources place the portion of the population under 15 years of age at 35 percent in Ethiopia. The population portion over 60 was taken at eight percent. On this basis, the assumed portion of population of working age in Ethiopia (15 to 60 years of age) amounts to about 57 percent. If the upper limit of 60 years were dropped to 56 years--in other words, the working age would be from 15 to 56 years--the percentage of people of working age would


LOCATION MAP
BLACK SEA
U.S.S.R.
CASPIAN SEA
TURKEY
MEDITERRANEAN
SYRIA
IRAQ
IRAN
SINAI
PERSIAN GULF
LIBYA
EGYPT
ARABIA
RED SEA
YEMEN
ADEN
SUDAN
GULF OF ADEN
ETHIOPIA
SOMALI REPUBLIC
CONGO
UGANDA
KENYA
SOMALI REPUBLIC
Adapted from "Map of Ethiopia" printed in Great Britain, but with revisions to meet current conditions.
RED SEA
GULF OF ADEN
FRENCH SOMALILAND
Strait of Bab el Mandeb
SUDAN
SOMALI REPUBLIC
KENYA
UGANDA
BEGEMIDIR
TIGRE
GOJJAM
WELLEGA
SHEWA
ADDIS ABABA
ARUSI
HARAR
BALE
KEFA
GAMU GOFA
SIDAMO
LUBABOR
Nora I Archipelago
Dahlak Kabir I
L. Tana
L. Zeai
L. Abaya
L. Stefanie
L. Rudolf
L. Abbe
Dire Dawa
Harar
Jijiga
Dessie
Gondar
Asmara
Massawa
Addis Ababa
EXPLANATION
Perennial river & stream
Seasonal river & stream
International boundary
Principal airport
Blue Nile investigation boundary
Primary all-weather roads
Primary dry-weather roads
Railroad
Swamp Area
Load Centers
SCALE OF KILOMETERS
CASE B
MAP OF ETHIOPIA
SHOWING
ELECTRIC POWER LOAD CENTERS
Feb. 29, 1963
4.0-BN-171



See Drawing No. 4.0-BN-29 for Population Density of Blue Nile River Basin.

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST. AGENCY FOR INT. DEV. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS
ESTIMATED POPULATION TREND

DRAWN C.L. Curtis ..... SUBMITTED C.L.C.
TRACED Assefa Ashagre RECOMMENDED P.W.K.
CHECKED C.L.C. - G.V.J. APPROVED C.E.B.

Addis Ababa Ethiopia | MAY 30, 62 (I.C.) | 4.0—BN—39

drop to 54.5. Table VII-4 provides some information on the age structure in Ethiopia as compared with several other countries.

TABLE VII-4 - ESTIMATED AGE STRUCTURE IN ETHIOPIA COMPARED WITH DATA FOR SOME OTHER COUNTRIES 1/

Country	Percentage of population below 15 yrs	Percentage of population over 60 yrs	Percentage of working population 15 - 60 yrs	Percentage of working population 15 - 55 yrs
Ethiopia	35	8	57	54.5 2/
Ghana	36.6	5.4	58	-
Southern Rhodesia	27.4	8.7	63.9	-
Turkey	39.6	6.2	54.2	-
England	15.5	11.8	71.7	-
U.S.A.	20.1	11.7	69.2	-

1/From United Nations Demographic Yearbook, 1951.
2/The population between 55 and 60 years is assumed to be 3.5 percent.

Considering the country as a whole, over 90 percent of the population is engaged in agricultural pursuits. The other 10 percent can be considered as supplying the labor needs of government, commercial and industrial enterprises, and various miscellaneous categories. In the 10 percent group would fall the labor employed in urban areas. By far the largest urban area, of course, is Addis Ababa, and according to the Ministry of Commerce and Industry, in 1960 there were about 60,500 persons gainfully employed in the city. Percentagewise, this labor force was distributed as follows:

Domestic service	24.75 percent
Civil service (Government)	21.50
Commerce	17.25
Manufacture	15.00

Drawing No. 4.0-BN-40 gives an indication of those employed in various types of industries in the 13 provinces, and perhaps 75 percent of those shown are located in the Addis Ababa Complex. In the Blue Nile River Basin, as shown by examining Drawings No. 7.2-BN-1 and 4.0-BN-29, the predominantly agricultural areas having the greatest population density occur along the northern and northeastern

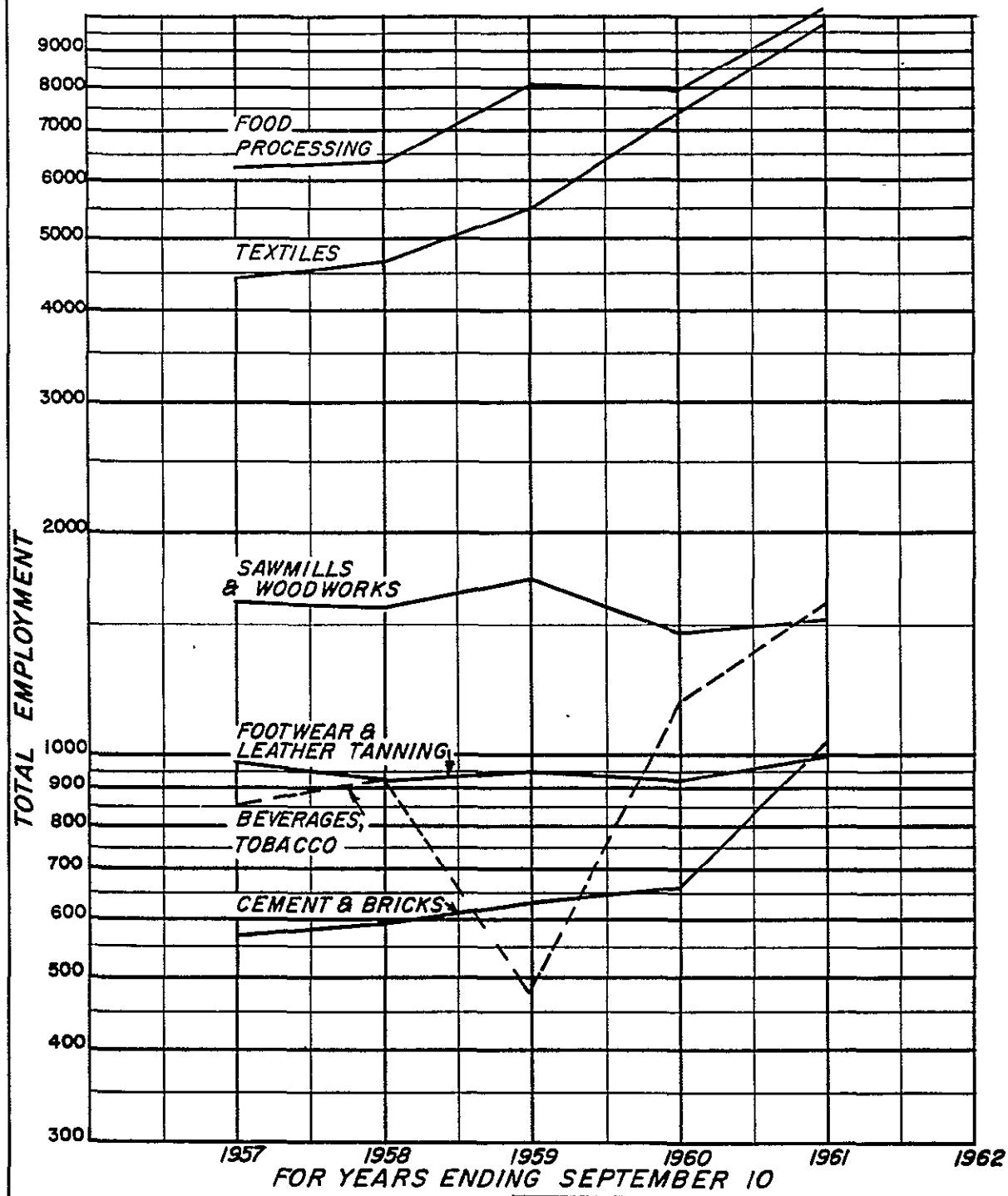
168

sides of Lake Tana, along the Bahir Dar-Addis Ababa highway, and along the inside loop of the Blue Nile River on the highlands. Many of these agricultural areas, which are located in the heavy population zone, are nearly saturated now, relative to the number of people that the land can support with a decent standard of living. Therefore, it is reasonable to expect that while the heavily populated areas will remain substantially static, new areas will have to be opened up for agricultural purposes and the development of new industry will be required to provide jobs for the remaining excess population.

Regarding the future labor force in Ethiopia, some general conclusions can be reached. Based upon a 1960 population of about 20,000,000 in the Empire, including Eritrea, the population will probably double to 40,000,000 by the year 2000. As stated before, the present labor force is 90 percent engaged in the agricultural industry. With the trend toward urbanization and correlary development of industry that is anticipated by the year 2000, some authorities conservatively estimate that 65 to 70 percent of the population will, at that time, be engaged in agricultural activities. This means that the present 10 percent of nonagricultural occupations will increase to at least 30 to 35 percent by the year 2000. On this basis, the rate of increase for nonagricultural jobs would average around 150,000 to 170,000 jobs per year. On the other hand, the rate of increase in agricultural jobs would be about 500,000 per year. The opening up of new lands to farmers by appropriate redistribution, by controlling diseases and other problems in certain undeveloped locations, and by providing water and power from multipurpose projects in still other areas will generally take care of the anticipated annual rate of increase in agricultural fields. But the rate of increase in the nonagricultural fields will have to be provided for in industry, and industry needs electric power in abundant and economical quantities. It is apparent that a reservoir of labor is available for industrial expansion.

Natural Resources

Ethiopia's greatest resource is its land, which is and can be used for agricultural purposes. Using the F.A.O. figures on percentage distribution, the land-use estimates in Table VII-5 are derived.



NOTES

1. Source: Ethiopian Economic Review 1-5
2. Excludes: Smaller miscellaneous Industries
3. Excludes: Eritrea — 13 Provinces only

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF STAGENCY FOR INT DEV. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

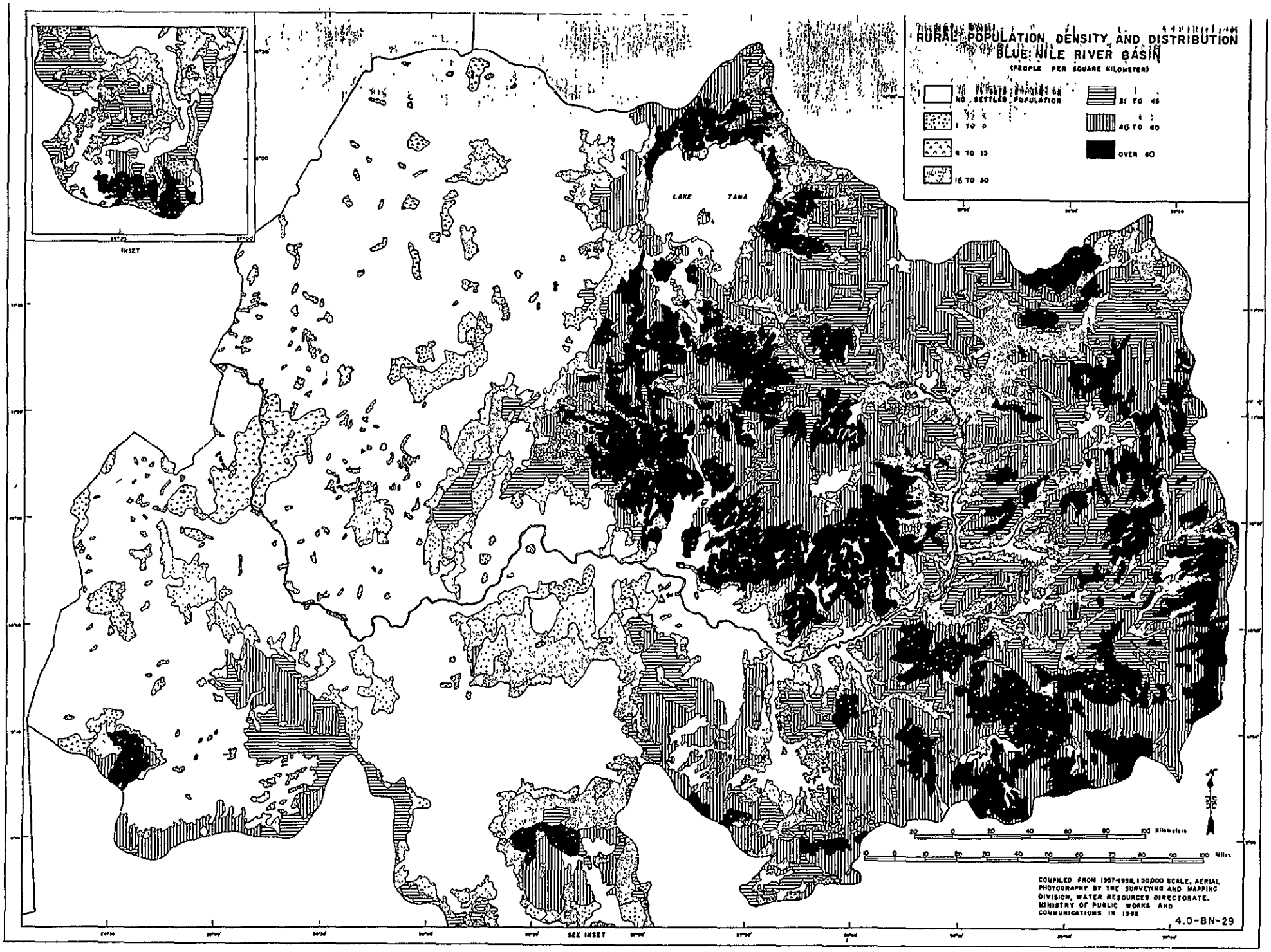
ELECTRIC POWER LOAD ANALYSIS

EMPLOYMENT

MANUFACTURING INDUSTRIES

DRAWN C.L. CURTIS SUBMITTED C.L.C.
TRACED MASRESHA RECOMMENDED P.W.K.
CHECKED C.L.C. APPROVED C.L.C.

Addis Ababa Ethiopia JUNE 1, 1962 4-0-BN-40


RURAL POPULATION DENSITY AND DISTRIBUTION
BLUE NILE RIVER BASIN
(PEOPLE PER SQUARE KILOMETER)
NO SETTLED POPULATION
1 TO 5
6 TO 15
16 TO 30
31 TO 45
46 TO 60
OVER 60
LAKE TANA
INSET
SEE INSET
Kilometers
Miles
COMPILED FROM 1957-1958, 1:30,000 SCALE, AERIAL PHOTOGRAPHY BY THE SURVEYING AND MAPPING DIVISION, WATER RESOURCES DIRECTORATE, MINISTRY OF PUBLIC WORKS AND COMMUNICATIONS IN 1962
4.0-BN-29

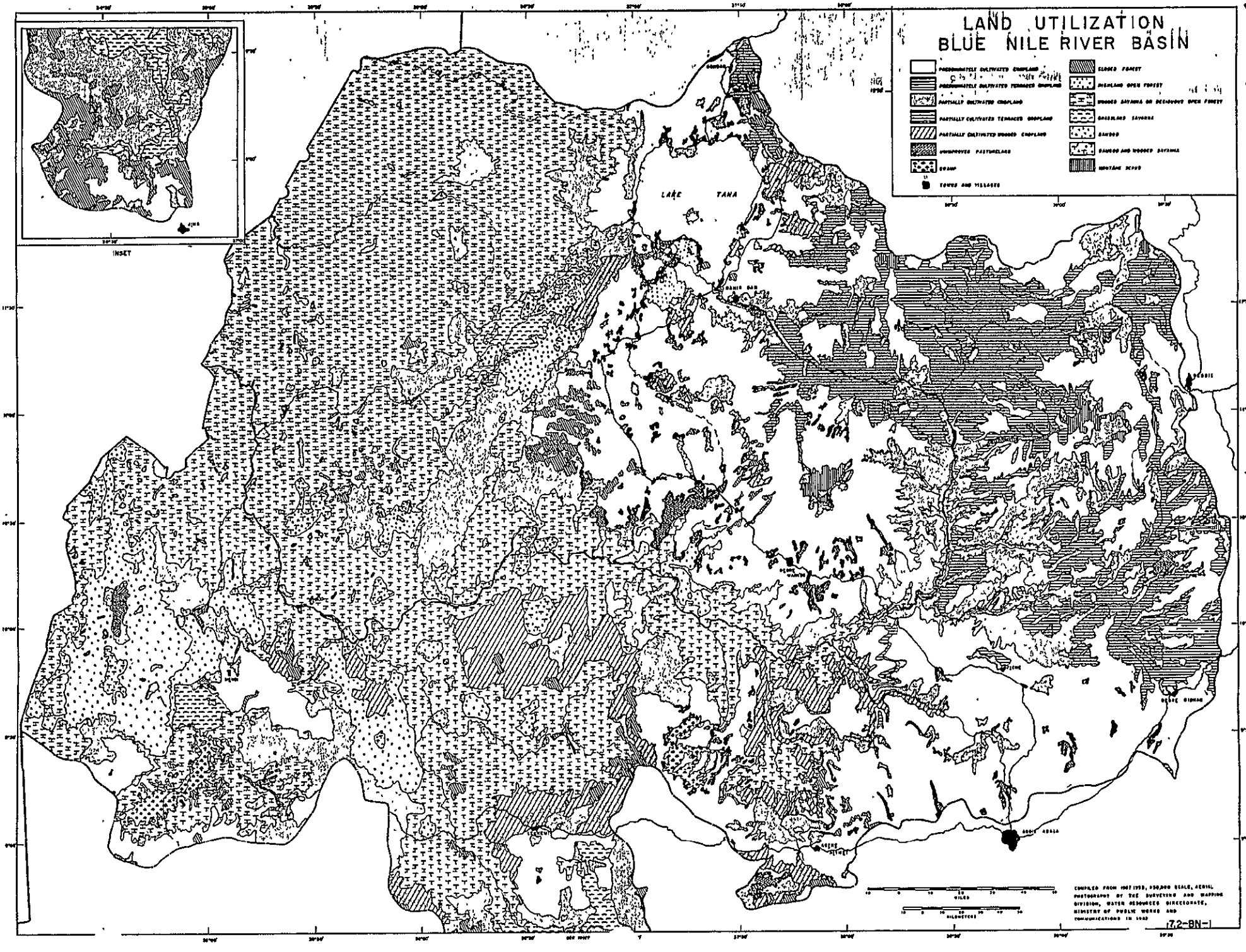

LAND UTILIZATION
BLUE NILE RIVER BASIN
PREDOMINATELY CULTIVATED CROPLAND
PREDOMINATELY CULTIVATED TERRACED CROPLAND
PARTIALLY CULTIVATED CROPLAND
PARTIALLY CULTIVATED TERRACED CROPLAND
PARTIALLY CULTIVATED WOODED CROPLAND
UNIMPROVED PASTURELAND
SWAMP
TOWNS AND VILLAGES
CLOSED FOREST
HIGHLAND OPEN FOREST
WOODED SAVANNA OR DECIDUOUS OPEN FOREST
GRASSLAND SAVANNA
BAMBOO
BAMBOO AND WOODED SAVANNA
MONTANE SCRUB
LAKE TANA
INSET
MILES
KILOMETERS
COMPILED FROM 1967-1970, 1:50,000 SCALE, AERIAL PHOTOGRAPHY BY THE SURVEYING AND MAPPING DIVISION, WATER RESOURCES DIRECTORATE, MINISTRY OF PUBLIC WORKS AND COMMUNICATIONS IN 1980
7.2-BN-1

TABLE VII-5 - LAND-USE AREAS

Land use	F.A.O. 1/ estimates (percent)	Hectares using F.A.O. percentages
Permanent meadows and pastures	49.59	60,499,800
Cultivated	9.70	11,834,000
Potentially productive	7.30	8,906,000
Forested	3.56	4,331,000
Wasteland	29.85	36,429,200
Totals	100.00	122,000,000

1/As reported in Ethiopian Observer, Volume V, No. 2.

The irrigable areas of the Finchaa and Amarti-Neshe Projects total 23,490 hectares and would eventually supply agricultural products for industrial processing, probably in Addis Ababa. This would be an example of "potentially productive" land placed into production and represents two potential power load possibilities--need for electricity by the new project farmers and need for electricity at Addis Ababa, for example, to process certain agricultural commodities.

There are good natural forest areas within reach of the Jima and Addis Ababa Complex load centers. The internal lumber market,* shows a present annual capacity of 40,000 cubic meters. With the rate of annual increased requirements being about 15 percent, the market requirements would be about 70,000 cubic meters within five years. At present, there are 22 major sawmills, and to meet the rising demand for wood products this number would have to be gradually enlarged, which factor must be considered in the power market analysis, as electricity is an economical source of energy for operating these mills. (At present, there is only one large mill, that at Ambo, in the Blue Nile River Basin.) There is now only one plywood factory, at Addis Ababa, and in order to meet the immediate needs of the country, two or three more such veneer mills will be required, processing about 50,000 cubic meters of veneer logs per year. Bamboo thickets cover several thousand

*Includes all imports as well as domestic production, whereas data included under "Development of Electric Energy Use" refer only to internal development, the only pertinent segment that concerns electric energy requirements.

hectares which may be within economical transportation distance of Jima, Addis Ababa, and Lekkemt. Bamboo is useful for the manufacture of paper and related products. Tannin is available from some of the species of trees and is needed for the processing of hides, important to the leather industry centered mainly in Addis Ababa.

Until 1962, no commercial mining except for some gold had been developed within the Blue Nile River Basin. In late 1962, preparatory steps were being taken for mining limestone for a cement mill being constructed in the Addis Ababa Complex (at Akaki). In Eritrea there are deposits of the following minerals:

Sodium chloride
Sylvite) potassium salts
Carnallite)
Magnesium chloride
Sulphur
Iron ore (hematite)

Some can be brought within economical reach of Assab by completion of future highway programs.

Several large lakes within Ethiopia contain different varieties of fish, some of which are of very poor quality. The inland fishing industry is very poorly developed at present, but the sea fisheries are better, principally at Assab and Massawa. Some inland lakes and rivers do not contain large quantities of fish because of the high sodium content of the water. Commercial fishing in other fresh water lakes and rivers, such as Lake Tana, Lake Langano, Lake Awasa, Lake Abaya (Margharita), Lake Rudolph, the Awash River, and others, could contribute much to an enlargement of the food supply for the population as a whole. With this and the export market in mind, the second five-year plan proposes to start considerably extending fishing as a branch of the national economy. Studies will be made during this period to obtain as much information as possible regarding the quantity and species of fish in the coastal water near the Assab and Massawa areas. Also, similar studies will be conducted concerning lake waters along the Mojo-Awasa route.

Principal Economic Activities

Government planners hope to change Ethiopia from a predominantly subsistence agricultural economy to an up-to-date, efficient, agricultural-industrial one by the year 1982. To achieve this, it is hoped to maintain a rate of economic growth of about four or five percent per year on an average. The Gross National Product

and corresponding rate of growth are shown by Table VII-6 for the 20 years in the future. Over 12 billion Ethiopian dollars (total from government and private sources) will have to be invested over the next 20 years, as indicated by Table VII-7, according to the Office of the Planning Board, in order to achieve these goals. If this is the objective, it can only be achieved by a corresponding rapid acceleration in the construction of facilities to provide electrical energy to the principal industrial load centers. Perhaps 80 percent of this industrial development will occur in the Addis Ababa-Nazret area of the Addis Ababa Complex for several reasons.

Agriculture. Although there will be a substantial shift toward more industrialization within 20 years, agriculture has traditionally been the foundation of the Ethiopian economy, and the livelihood of perhaps 90 percent of the country's population is derived from basic farming activities or from the processing and exchange of farm produced crops and goods. Table VII-8 indicates the forecast trend in the export of certain agricultural products, which is an indication of a trend in anticipated future agricultural production.

TABLE VII-6 - GROSS DOMESTIC PRODUCT ESTIMATES OVER THE 20-YEAR PERIOD 1/

Periods	Gross domestic product (in million Eth$, 1961 prices)	Index number	Rate of growth
1958-1962	2,130	100	3.2
1963-1967	2,632	124	4.3
1968-1972	3,310	155	4.7
1973-1977	4,270	200	5.2
1978-1982	5,650	265	5.8

1/Second Five Year Development Plan.

TABLE VII-7 - ESTIMATED INVESTMENT DURING A 20-YEAR PERIOD 1/

Five year plan	Total investment (million Eth$)	Five year investment as percent of total	Index number (First Plan = 100)
Second	1,696	13.4	202
Third	2,420	19.1	288
Fourth	3,516	27.7	419
Fifth	5,050	39.8	601
Total	12,682	100.0	

1/Second Five Year Development Plan.

TABLE VII-8 - FORECAST TREND IN EXPORT OF CERTAIN AGRICULTURAL PRODUCTS 1/

Produce	In million Eth$, 1962 prices			Index (1962 = 100)
	1962 (Actual)	1967	1963-67	
Coffee	99.6	135.0	601.0	135
Hides and skins	22.7	28.7	125.0	126
Pulses	17.0	18.9	90.0	111
Oilseeds	14.9	21.2	96.0	142
Chat	10.2	11.0	54.0	107
Fruits and vegetables	4.7	6.2	27.0	131
Other	13.3	16.0	78.0	118
Total	182.4	237.0	1,071.0	

1/Second Five Year Development Plan.

Industry. Industrial activity in Ethiopia is confined primarily to processing agricultural commodities, producing foods and beverages, manufacturing some items for domestic consumption--tobacco products, footwear and leather products, and producing mineral products--cement, bricks, salt, and others. Drawings Nos. 4.0-BN-30, 4.0-BN-31, and 4.0-BN-32 show gross industrial production comparisons over a three- or four-year period.

Table VII-9 summarizes industry in the 13 provinces, exclusive of Eritrea, for the year ending September 10, 1961. A study of Table VII-10 will indicate that for the 11-year period, 1951 to 1961, inclusive, the volume of industrial production for all of Ethiopia, excluding Eritrea, increased over 4.5 times, and in the same period the production of electricity increased more than five times. During the period 1956 through 1961 (six years), the total manufacturing output of Eritrea increased by about 1.4 times, and that of the remaining 13 provinces more than 1.8 times during the same period. The total for the Empire of Ethiopia during the same period--that is, from 1956 through 1961--showed an increase in the output of manufacturing industries amounting to 1.7 times.

During the same six-year period, the output of electricity increased as follows:

Eritrea	1.6 times
Thirteen provinces	2.4 times
Total Ethiopia	2.2 times

During the period 1963-1967, the government planners foresee that the total output of the manufacturing industry would, on the whole, be tripled. Production of the more important industrial products is forecast in Table VII-11. Table VII-12 shows that before 1963, the investment in the forecast manufacturing industry was only about six percent. By 1967, this will have reached 19 or 20 percent annually and will probably hold to that figure for some time in the future. A tabulation of 103 new industrial projects to be completed and 18 more reconstructed during the period 1963-1967 is shown in Table VII-13. Of those to be completed, about 94 will actually go into operation within the same period as shown by Table VII-14.

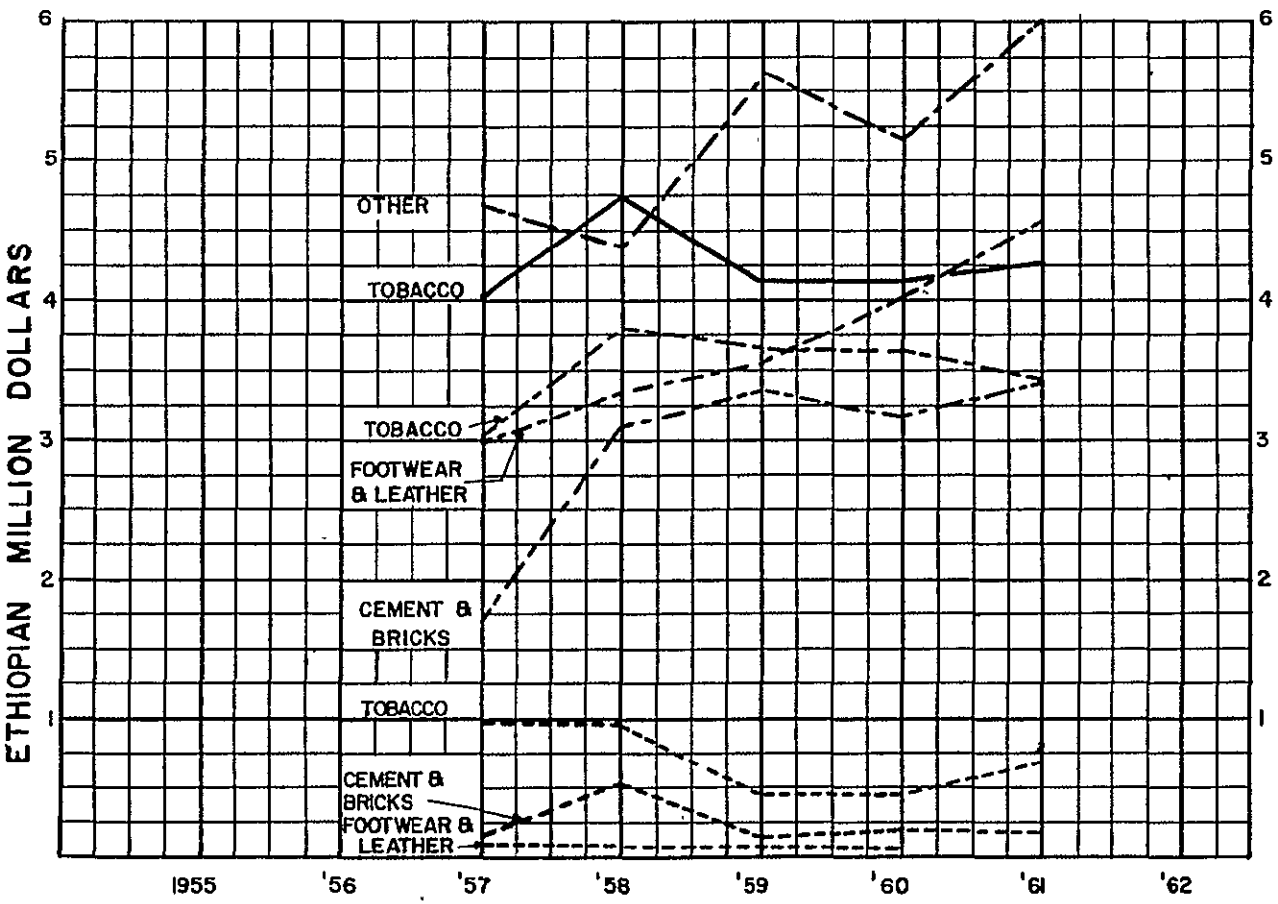
The emphasis being put on industrial development will require a corresponding increase in the availability of electricity supplies for supporting the increased industrial output. Some government planners foresee a 340 percent increase in the amount of electricity used for industrial purposes, using the year 1962 as a

TABLE VII-9 - SUMMARY OF INDUSTRY IN THE 13 PROVINCES (YEAR ENDED SEPT. 10, 1961)

Industrial Group	Number of establishments in operation		In thousands of Ethiopian dollars				
	1960	1961	Purchase of materials	Value of fixed assets 1/	Capital expenditure	Value of production: Gross	Value of production: Net
Food products	21	22	14,810	50,195	10,270	25,630	9,445
Flour, macaroni, biscuits	8	8	5,010	4,689	44	6,170	960
Edible oils and products	10	11	3,912	2,396	61	4,984	851
Sugar, tomato canning	2	2	5,882	41,610	10,065	13,816	7,017 2/
Slaughter and preparation of meats	-	-	6	1,500	100	660	617
Beverages	20	20	1,931	5,796	450	5,643	3,448
Alcohol, beer, liquors	6	6	549	3,036	235	3,062	2,362
Wines	7	7	1,023	1,003	33	1,569	489
Soft drinks and carbonated water	7	7	359	1,757	182	1,012	597
Tobacco manufactures	1	1	758	1,376	66	3,448	2,672
Textiles	8	9	18,569	15,868	2,934	32,722	13,053
Spinning, weaving, and finishing	3	4	16,400	14,095	2,825	28,232	10,941
Knitting mills, etc.	3	3	70	49	-	295	221
Cordage, sacks, rope, and twine	2	2	2,099	1,724	109	4,195	1,891
Leather tanning and footwear 3/	5	5	2,713	2,170	236	4,692	1,880
Sawmills, plywood, etc.	6	7	389	1,041	668	1,798	1,304
Furniture and fixtures 4/	3	3	1,012	485	52	1,660	633
Printing and publishing 5/	6	6	937	732	74	1,938	931
Chemicals and chemical products	-	-	192	715	165	606	392
Nonmetallic mineral products	3	3	304	1,880	84	3,477	2,906
Bricks	2	2	-	147	7	409	318
Cement	1	1	304	1,733	77	3,068	588
Miscellaneous manufactures	4	4	126	518	510	194	60
Total manufactures	77	80	41,741	80,776	15,509	81,808	36,724
Electricity	13	15	1,124	51,100	3,700	6,126	4,688
Total industry (excl. mining, construction, coffee and grain cleaning)	90	95	42,865	131,876	19,209	87,934	41,412

Source: Central Statistical Office.

1/Includes plant and machinery, vehicles, land, and buildings.
2/Excludes an estimated E$5 million of sugar cane grown on plantations of the industrial concern.
3/Excludes small shoemakers and shoe repairers.
4/Excludes small carpentry shops.
5/Excludes Berhanena Selam Printing Press in Addis Ababa.



—·—· Ethiopia's 13 Provinces
---- Eritrea
—— Empire, total, where shown

NOTES

1 Source : Ministry of Commerce and Industry

2 For total gross industrial production, see Drawing No.4.0-BN-32.

3 For gross industrial production selected industries see Drawing No.4.0-BN-31.

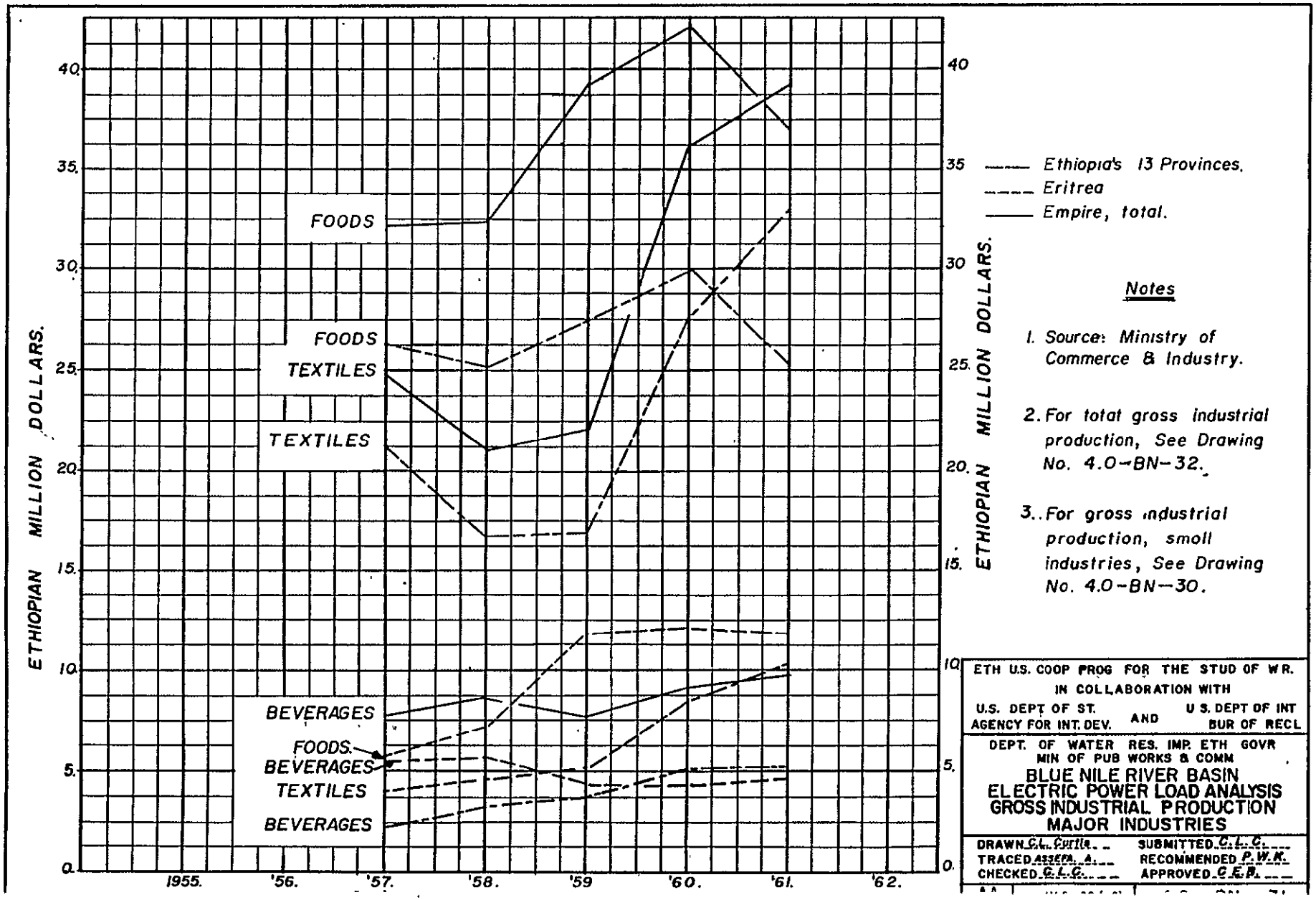
4 "OTHER" includes lumber, furniture, printing & chemicals.

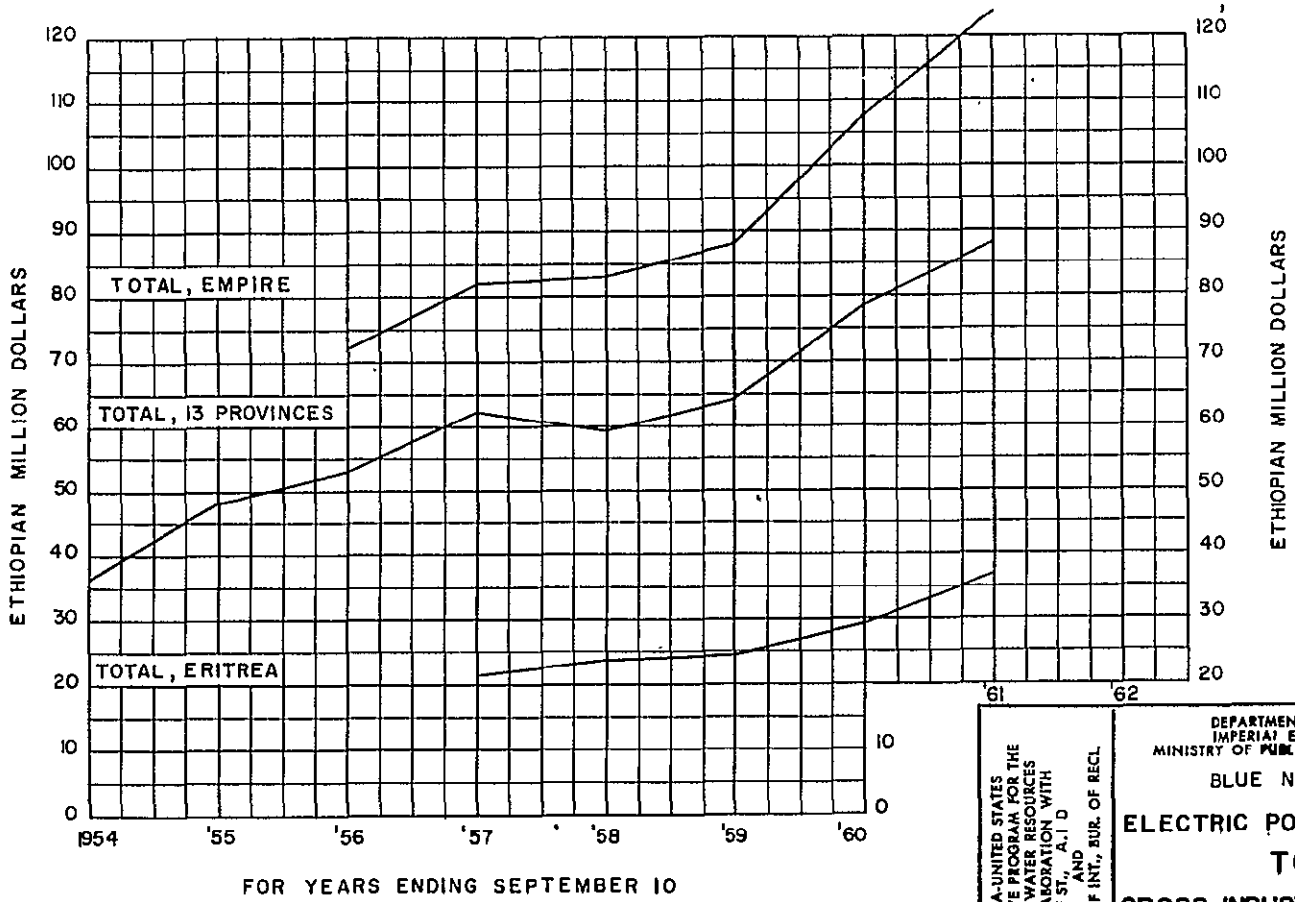
ETH-US COOP PROG. FOR THE STUD. OF W. R.
IN COLLABORATION WITH
U.S. DEPT OF ST INT COOP ADMIN. AND U.S DEPT. OF INT. BUR. OF RECL
DEPT. OF WATER RES IMP ETH GOVR.
MIN OF PUB WORKS & COMM
BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS
GROSS INDUSTRIAL PRODUCTION
SMALL INDUSTRIES

DRAWN C. L. Curtis SUBMITTED C. L. C.
TRACED Gebrechristos RECOMMENDED P. W. K.
CHECKED C. L. C. APPROVED C. E. B.

A A May. 21-1962 (1:C) | 4.0-BN-30


ETHIOPIAN MILLION DOLLARS.
40.
35.
30.
25.
20.
15.
10.
5.
0.
1955.
'56.
'57.
'58.
'59
'60.
'61.
'62.
FOODS
FOODS
TEXTILES
TEXTILES
BEVERAGES
FOODS.
BEVERAGES
TEXTILES
BEVERAGES
Ethiopia's 13 Provinces.
Eritrea
Empire, total.
Notes
1. Source: Ministry of Commerce & Industry.
2. For total gross industrial production, See Drawing No. 4.0-BN-32.
3. For gross industrial production, small industries, See Drawing No. 4.0-BN-30.
ETH U.S. COOP PROG FOR THE STUD OF W.R.
IN COLLABORATION WITH
U.S. DEPT OF ST. AGENCY FOR INT. DEV.
AND
U.S. DEPT OF INT BUR OF RECL
DEPT. OF WATER RES. IMP. ETH GOVR
MIN OF PUB WORKS & COMM
BLUE NILE RIVER BASIN
ELECTRIC POWER LOAD ANALYSIS
GROSS INDUSTRIAL PRODUCTION
MAJOR INDUSTRIES
DRAWN C.L. Curtis
TRACED
CHECKED C.L.C.
SUBMITTED C.L.C.
RECOMMENDED P.W.K.
APPROVED C.E.P.



NOTES

1. Excludes production of rock salt in Danakil plains, certain printing presses, and some coffee and grain cleaning industries.
2. Source: Ministry of Commerce & Industry & United Nations
3. For gross production of selected industries, see Drawings No. 4.0-BN-30 and 4.0-BN-31

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., A.I.D. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

TOTAL

GROSS INDUSTRIAL PRODUCTION

DRAWN G.L. CURTIS
TRACED A.N. MUSSA
CHECKED G.L.G.
SUBMITTED G.L.G.
RECOMMENDED P.W.K.
APPROVED G.E.B.

Addis Ababa Ethiopia | 21 MAY 1962 | 4.0-BN-32

TABLE VII-10 - INDEX OF ECONOMIC TREND OF INDUSTRIAL PRODUCTION (1955 = 100)

For the Empire of Ethiopia, 1956 through 1961																		
	The 13 Provinces						Eritrea Province 1/						Total, Ethiopia					
Industrial group	'56	'57	'58	'59	'60	'61	'56	'57	'58	'59	'60	'61	'56	'57	'58	'59	'60	'61
Manufacturing																		
Foods	109	128	132	146	162	158	84	69	92	77	132	89	103	113	122	129	155	141
Beverages and tobacco	114	114	122	154	179	216	108	112	117	107	103	106	113	114	121	142	160	189
Textiles	112	128	115	123	185	227	-	100	152	164	183	243	112	121	124	133	185	231
Leather goods	151	168	168	162	182	193)												
Building materials, etc.	117	91	115	93	100	128)	83	80	87	55	89	122	112	103	113	94	112	135
Miscellaneous	84	69	62	56	69	70)												
Total Manufacturing	112	124	124	134	165	183	92	102	124	110	145	141	107	119	124	128	160	173
Electricity (both public utility and industrial firms)	115	133	145	165	190	240	101	110	117	125	142	163	110	125	135	155	178	215
Total Mfg. and Elec.	112	123	123	134	163	181	93	103	122	111	142	139	107	118	123	128	158	171

For the 13 Provinces, 1951 through 1961 (1950 = 100) 2/											
Industrial group	'51	'52	'53	'54	'55	'56	'57	'58	'59	'60	'61
Manufacturing											
Foods	104	100	119	137	223	242	286	295	325	361	352
Beverages and tobacco	121	152	188	204	199	227	227	243	306	356	430
Textiles	72	197	267	313	395	444	507	452	485	731	895
Leather goods	113	191	197	206	213	322	357	358	346	388	411
Building materials, etc.	102	100	114	156	221	259	201	254	205	220	283
Miscellaneous	113	112	126	136	161	134	111	100	90	111	113
Total Manufacturing	101	133	163	187	249	280	308	308	333	410	455
Electricity (both public utility and industrial firms)	105	119	142	167	183	210	243	265	371	428	538
Total Mfg. and Elec.	101	130	161	184	235	263	288	290	314	382	425

Source: Central Statistical Office.

1/North Eritrea load center.
2/Primarily Addis Ababa complex.

TABLE VII-11 - 1967 PRODUCTION GOAL FOR SELECTED INDUSTRIAL PRODUCTS 1/

Article	Unit	Actual 1957	Actual 1962	Forecast 1967
Meat (frozen)	metric ton	683	5,500	35,000
Meat (canned)	metric ton	1,290	1,000	7,000
Sugar	metric ton	16,181	38,000	60,000
Salt	metric ton	132,292	158,000	275,000
Edible oil	metric ton	4,350	4,800	12,000
Flour	metric ton	23,000	24,000	51,000
Macaroni	metric ton	2,700	2,800	3,100
Beer	hectoliter	41,780	67,000	85,000
Wine	hectoliter	12,900	18,600	30,000
Cigarettes	1,000	252,000	370,000	500,000
Cotton fabrics	1,000 sq m	5,000	21,500	74,000
Rayon fabrics	1,000 sq m	--	--	6,000
Gunny bags	1,000	1,700	2,800	6,000
Shoes (leather)	pr	203,000	248,000	2,150,000
Shoes (canvas, rubber)	pr	--	--	1,300,000
Timber	cu m	16,300	12,500	20,000
Plywood	cu m	--	1,200	3,000
Furniture	Eth$ 1,000	350	450	1,300
Matches	1,000	11,800	16,000	25,000
Glass bottles	1,000	3,800	7,500	14,000
Cement	metric ton	26,860	29,000	210,000
Bricks	1,000	5,670	8,000	30,000
Mosaics	sq m	30,000	65,000	95,000

1/Second Five Year Development Plan.

19

TABLE VII-12 - INVESTMENT IN MANUFACTURING INDUSTRY BY YEARS[1]

Year	Investment (Eth$1,000)	As percent of total
Before 1963	25,560	6.0
1963	35,795	8.4
1964	57,445	13.5
1965	65,255	15.3
1966	74,795	17.6
1967	85,175	20.0
After 1967	81,925	19.2
Total	425,950	100.0

TABLE VII-13 - NUMBER OF INDUSTRIAL PROJECTS TO BE CONSTRUCTED--1963-1967[1]

Branch of Industry	Total	Breakdown	
		Completed or reconstructed	New projects
Food	29	3	26
Beverages	3	1	2
Tobacco manufacturing	2	1	1
Textiles	15	6	9
Leather and shoes	9	1	8
Wood	3	--	3
Building and nonmetal	16	3	13
Printing and publishing	2	1	1
Chemicals	22	1	21
Metals, production and fabrication, and electrical manufacturing	16	1	15
Other	4	--	4
Total	121	18	103

TABLE VII-14 - INDUSTRIAL PROJECTS TO BE PUT INTO OPERATION--1963-1967[1]

Year	Number of projects
1963	3
1964	19
1965	15
1966	24
1967	33
Total	94

1/Second Five Year Development Plan.

18

base. This increase would be for the period 1963-1967, inclusive. Until 1967 and perhaps a few years later, industrial production will primarily be geared to meeting consumer demands, although a start will be made in heavier industries, such as steel. A nucleus for the steel industry already exists, with the inauguration of a small Akaki steel mill in 1963, which depends primarily upon electricity for its energy requirements

Trade. Ethiopia is primarily an importer of manufactured goods and an exporter of agricultural commodities. In value, cotton textiles represent the largest single import item, and coffee constitutes more than half of all exports. This is shown by Drawings Nos. 4.0-BN-33, -37, and -43. The second major import in value is manufactured items, such as iron, steel, machinery, and tools, which have shown a steadily increasing trend in recent years; this same increase is also reflected in the increased import of vehicles, aircraft, and railway accessories. To a lesser degree, certain food items, such as drink and tobacco, have also been imported at increasing levels for the past few years. Next to coffee, hides and skins assume second place in export value, although the value of exported pulses has recently shown a marked increase.

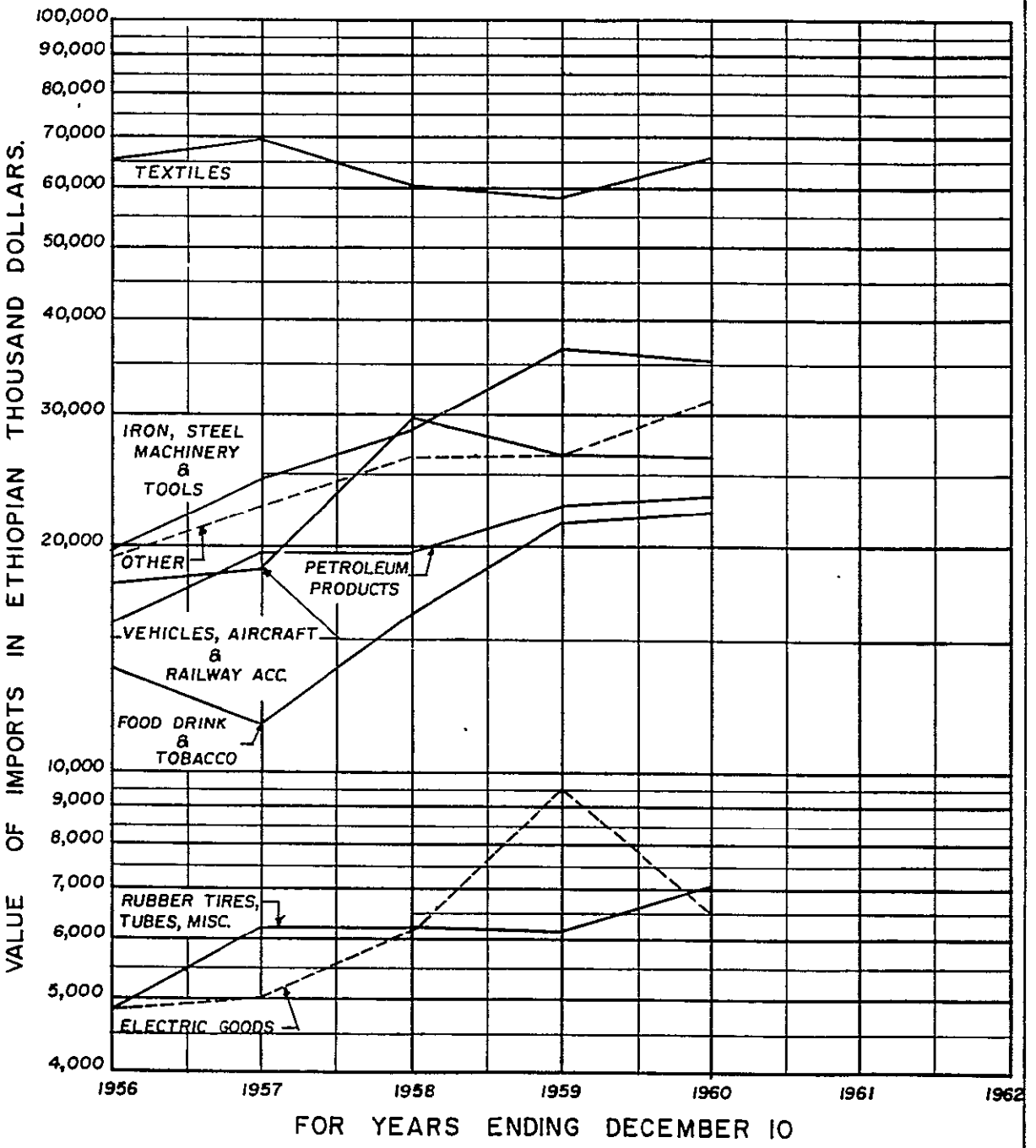
As shown by Drawing No. 4.0-BN-36, the value of imports has consistently exceeded the value of exports during the period 1959 through 1961, and it will also be seen that the value of exports has increased by 2.67 times and the value of imports more than three times during the decade 1950 to 1960.

The principal commercial cities in Ethiopia, in order of importance, are Addis Ababa, Asmara, and Dire Dawa. Dire Dawa is halfway between Addis Ababa and Djibouti, French Somaliland, and is the major town on the Addis Ababa-Djibouti railway. Addis Ababa is the focal point for both the distribution of imports and the collection of coffee, hides and skins, and other products for export. For this reason, all the principal firms engaged in foreign trade have their head offices in Addis Ababa.

The metric system is used in trade, but in local agricultural areas local units are used.

Government planners expect that foreign trade will constitute the third most important sector of the national economy, exceeded only by industrial and agricultural output. They recognize that, unless an accelerated sound foreign trade program is developed, the goals set for the agricultural and industrial expansion probably cannot be achieved. In the five-year period 1957 to 1962, inclusive,

19



Notes

1. Source: Ministry of Commerce and Industry, Addis Ababa
2. For the 13 Provinces.

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., AGENCY FOR INT. DEV. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

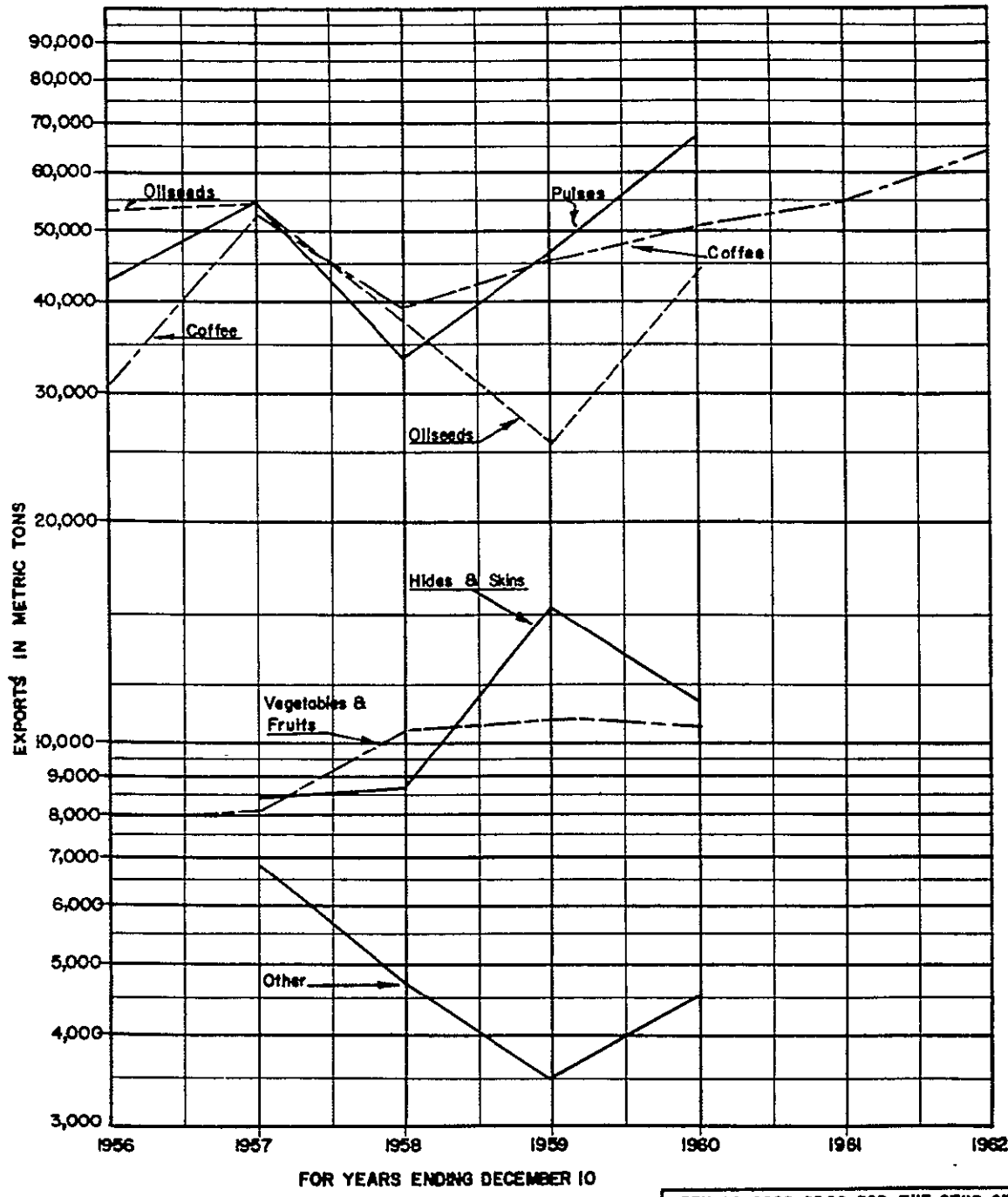
BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

MAJOR IMPORTS (DOLLAR VALUE)

DRAWN C.L. Curtis SUBMITTED C.L.C.
TRACED Assefa Ashagre RECOMMENDED P.W.K.
CHECKED C.L.C. - G.V.J. APPROVED C.E.B.

Addis Ababa Ethiopia | MAY 29 62(IC) | 4.0—BN—33



Notes

1. Source:

   Ministry of Commerce & Industry,
   Addis Ababa.

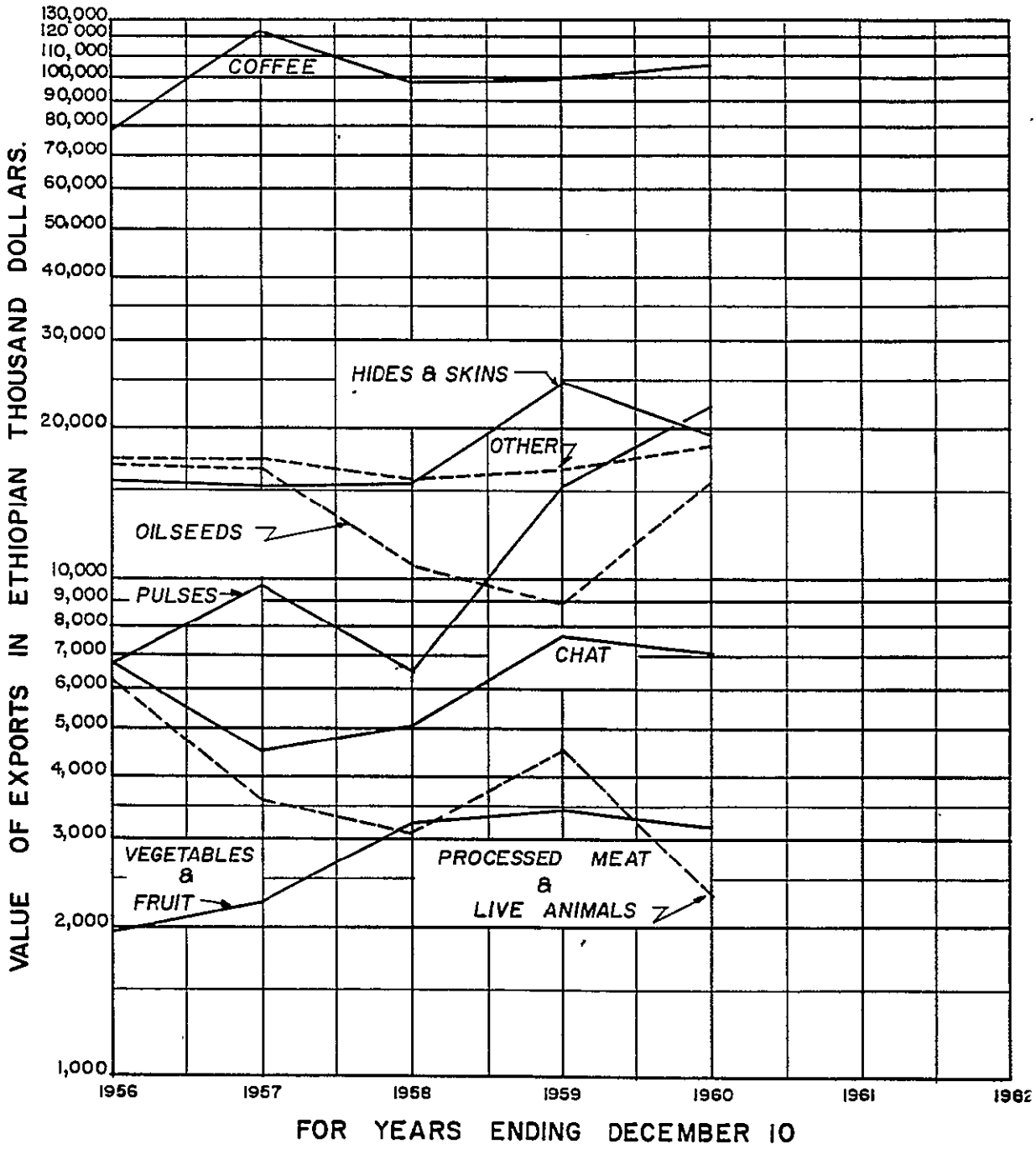
2. All major exports shown above are agricultural products and are for the 13 Provinces.

ETH. US COOP PROG. FOR THE STUD OF W. R
IN COLLABORATION WITH
U.S. DEPT. OF ST. AGENCY FOR INT DEV. AND U.S. DEPT. OF IN SUR. OF RECL.

DEPT. OF WATER RES. IMP. ETH. GOVR.
MIN OF PUB. WORKS & COMM.
BLUE NILE RIVER BASIN
ELECTRIC POWER LOAD ANALYSI
MAJOR EXPORTS (Volume)

DRAWN C.L. Curtis SUBMITTED C.L.C.
TRACED Berhe N. RECOMMENDED P. W. K.
CHECKED C.L.C. APPROVED C.E.B.

Addis Ababa Ethiopia | 15 May 1962 | 4-0-BN-37



NOTES

1. Source:
   Ministry of Commerce & Industry, Addis Ababa.
2. For the 13 Provinces.
3. See Drawing No. 4.0—BN—39.

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., AGENCY FOR INT DEV AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

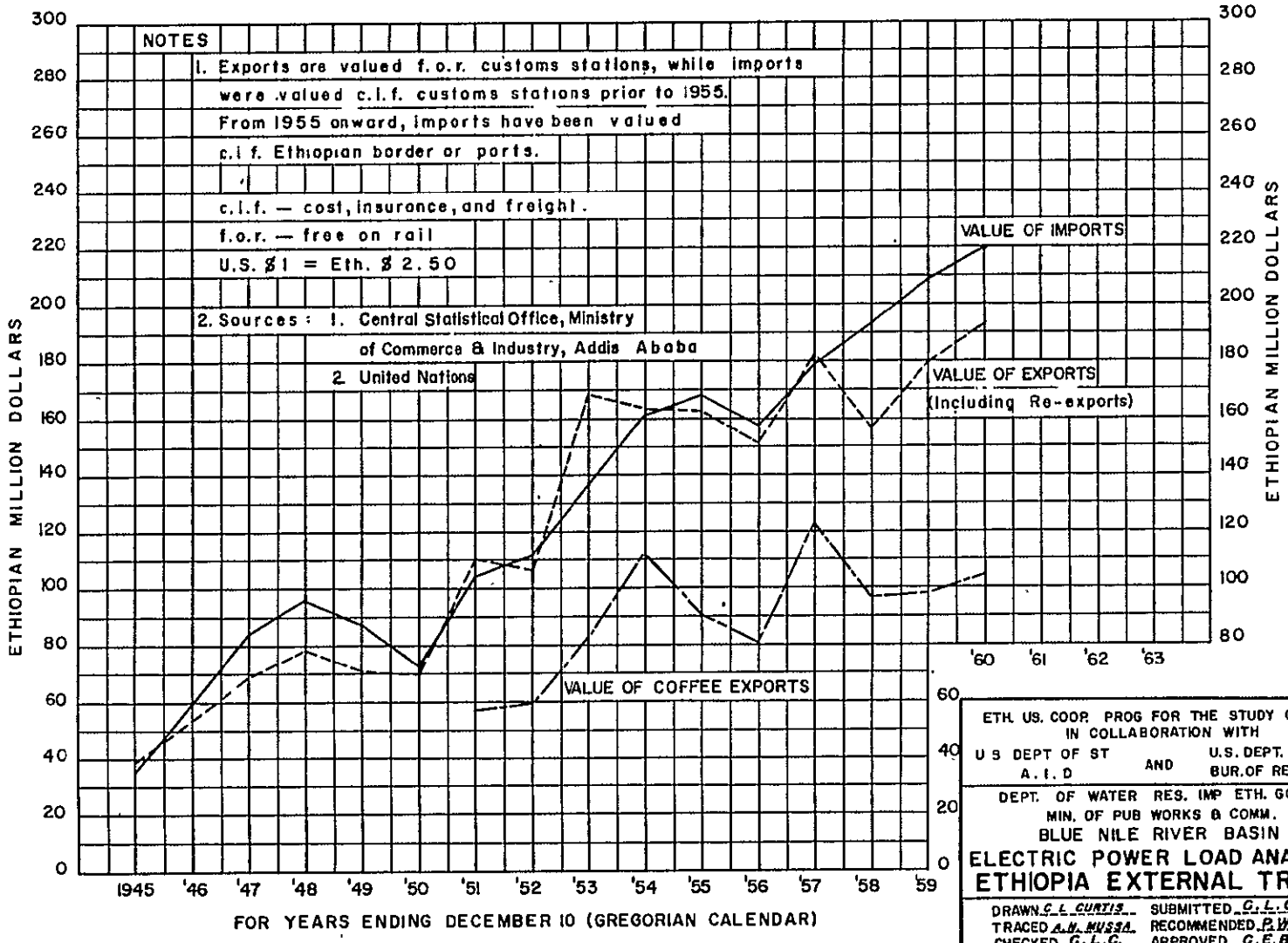
BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

MAJOR EXPORTS (DOLLAR VALUE)

DRAWN C.L. Curtis . . SUBMITTED C.L.C.
TRACED. Asnafo Ashagre ... RECOMMENDED P.W.K.
CHECKED C.L.C. . . APPROVED C.E.B.

Addis Ababa Ethiopia | MAY 11, 62 (I.C.) | 4.0—BN—43



ETH. US. COOR. PROG FOR THE STUDY OF WR. IN COLLABORATION WITH
U S DEPT OF ST A.I.D AND U.S. DEPT. OF INT. BUR. OF RECL.

DEPT. OF WATER RES. IMP ETH. GOVR.
MIN. OF PUB WORKS & COMM.

BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

ETHIOPIA EXTERNAL TRADE

DRAWN C. L. CURTIS SUBMITTED C. L. C.
TRACED A. H. MUSSA RECOMMENDED P. W. K.
CHECKED C. L. C. APPROVED C. E. B.

A.A. ETH 16 MAY 1962 4.0-BN-36

the geographical distribution of foreign trade was rather uneven. Of the total Ethiopian imports in a one-year period (1959-1960), Western Europe supplied 43.1 percent; the United States, 15 percent; Japan, 13.1 percent; Eastern Europe, 7.0 percent; India, 6.0 percent; and all African countries, 2.3 percent. The export pattern for the same period showed 26.6 percent of exports going to Western Europe; 38.1 percent to the United States; Eastern Europe, 3.1 percent; Japan, 2.6 percent; all African countries, 6.9 percent; and India, 1.0 percent. Export forecasts for the period 1962 to 1967 are for an increase from Eth$194.9 million to Eth$327 million, or about 60 percent, an average annual rate of increase of 11 percent. Imports may grow faster, and these have been forecast at Eth$419.2 million for 1967 as compared with Eth$234.2 million in 1962, a total increase of 79 percent or an average annual increase of 12.3 percent for the period. Exports will rely principally upon traditional agricultural products, but it is expected that an important start will be made on the export of new industrial products as well as those from the mining industry. Table VII-15 shows the trend in anticipated exports by various basic economic sectors. From this table, it is evident that the largest increase will occur in the export of industrial products, followed by mining. Table VII-16 shows where, within the manufacturing industries, the expected increases in large exports will take place.

Mining. Mineral production has remained rather static in the past several years, but exploration and development investments have continued at an increasing rate with the largest investment being made in the Dallol potash reserves where an American firm is developing the salt deposits. Mineral production for the past few years has been limited primarily to gold, platinum, limestone for cement manufacture, sodium chloride (salt), quartz sand, and a little manganese ore. In the period 1963 to 1967, substantial quantities of iron ore and potash are scheduled for production. Both of these deposits are in eastern Ethiopia, the potash near Dallol and the iron ore deposits to the northeast near the seacoast village of Mersa Fatma. Table VII-17 shows the proposed increases by years in mineral production to 1967. Table VII-18 shows the gross value of mineral production in dollars anticipated as a result of mineral production estimates given in Table VII-17.

At present, most oil exploration activities are centered on the east coast of Ethiopia in the Eritrean coastal zone and adjacent islands. Another oil exploration area being actively investigated is in the Ogaden. A small amount of platinum mining activity is under way at Yubdo, with gold mining operations centered mainly in the Adola area.

19

TABLE VII-15 - FORECAST TREND IN EXPORTS BY SECTORS[1/]
(IN MILLIONS OF ETHIOPIAN DOLLARS)

Sector	Actual		Forecast			Index percent 1962 = 100
	1962	Percent	1967	Percent	1963-1967	
Agriculture	182.4	93.6	237.0	72.3	1,071.0	129
Industry	10.2	5.2	80.0	24.2	185.5	784
Mining	2.0	1.0	10.0	3.0	38.1	500
Handicrafts	0.3	0.2	0.7	0.5	2.3	233
Total	194.9	100.0	327.7	100.0	1,296.9	

TABLE VII-16 - FORECAST TREND IN EXPORT OF INDUSTRIAL PRODUCTS[1/]
(IN MILLIONS OF ETHIOPIAN DOLLARS)

Basic branches of manufacturing industry	Actual	Forecast	
	1962	1967	1963 -1967
Food	9.6	62.5	159.9
Leather and shoes	--	9.0	10.1
Building and nonmetal	0.1	3.2	4.1
Chemicals	--	3.3	4.4
Other	0.5	2.0	7.0
Total	10.2	80.0	185.5

1/Second Five Year Development Plan.

191

TABLE VII-17 - SCHEDULED MINERAL PRODUCTION, BY YEARS (1963-1967)1/

Mineral	Unit	1963	1964	1965	1966	1967
Gold, concentrate	kg.	800	1,000	1,200	1,200	1,200
Platinum, concentrate	kg.	10	15	15	15	15
Iron ore	metric ton	--	--	--	--	200,000
Manganese ore	metric ton	2,000	2,000	2,000	2,000	2,000
Potash	metric ton	--	150,000	300,000	300,000	300,000
Salt	metric ton	25,000	25,000	25,000	25,000	25,000
Quartz sand	metric ton	2,000	2,000	2,000	10,000	12,000
Clays	metric ton	--	--	--	--	5,000
Asbestos	metric ton	--	--	500	1,000	1,000

TABLE VII-18 - FORECAST GROSS VALUE OF MINERAL PRODUCTION1/

Year	Gross value (Eth$1,000)	Index number (1963 = 100)
1963	2,730	100
1964	7,435	272
1965	12,285	450
1966	12,740	465
1967	16,935	620

1/Second Five Year Development Plan.

19

The Imperial Ethiopian Government follows the basic policy of developing its mineral resources to the greatest extent its somewhat limited means permit, and at the same time to allow private persons and companies, both Ethiopian and foreign, to participate in exploration and exploitation. The Government also encourages the development of mineral resources to the greatest extent possible to obtain raw materials for the development of heavy industry, because considerable emphasis is being put on industrial development.

Since the greater part of Ethiopia, especially in the southwest, is largely unexplored insofar as mineral reconnaissance is concerned, the I.E.G. believes that the possibility of obtaining favorable results from a stepped-up investigations program is good, and this optimism is reflected in Tables VII-17 and VII-18.

Transportation and Communications. Two principal railroads are now in operation, the Addis Ababa-Djibouti Railroad and the Agordat-Massawa Railway. Both are diesel and diesel-electric operated. The Agordat-Massawa Railway is under the jurisdiction of the Ropeway Administration in Eritrea, while the Addis Ababa-Djibouti Railroad is operated by the Chemin de Fer Franco-Ethiopian, owned jointly by Ethiopia and France. The Massawa railway is 950-mm. track gage and is about 306 kilometers long, while the Djibouti railroad has 1,000-mm. track gage and is 781 kilometers in length. The latter handled about 44 percent of the total Ethiopian imports in 1959.1/ The Agordat-Massawa Railway serves the extreme northern portion of the country and Asmara, second largest city; the Addis Ababa-Djibouti Railroad serves the largest city, Addis Ababa, and the central portion of the country. The two are not connected. The total transport on both railroads in 1961 was 463,000 tons of freight and 700,000 passengers.

During the decade 1950-1960, more than 4,000 kilometers of automobile roads were opened to traffic, and traffic increased by more than 130 percent, with the number of registered motor vehicles increasing five times. The construction and maintenance of highways are of vital importance to any country, because adequate roads accelerate the economic development in the areas they serve. They are also important for national defense, and they will provide a means to consolidate the outlying regions in the Empire.

There are two main seaports with modern facilities--Assab and Massawa, both on the Red Sea and connected to the inland

1/Table 1(g) from Ethiopian Economic Review No. 2, June 1960.

19

area by good roads. Port traffic for a nine-year period at the port of Assab is shown by Table VII-19. A recently completed modernization program has improved port facilities.

Ethiopian Airlines, with head offices in Addis Ababa, provides internal air service throughout the Empire to some 20 or more airports. In addition, regular international services are provided to other places in Africa, Asia, and Europe.

Inland water transport is very small, being limited primarily to Lake Tana and to the Baro River. The latter, in the southwestern part of the country, has as its principal port the town of Gambela. From there, small boats sail down the river as far as its mouth on the White Nile near the town of Malakala in the Sudan and continue along the White Nile. Thus, part of the Ethiopian foreign trade is carried on with the Sudan over the Baro River. Small harbors and lighthouses for day and night traffic on Lake Tana have been built. For the future, opening of traffic associated with the development of fishing in Lake Abaya is a possibility.

At one time, posts, telegraph, and telephones were under the Post, Telegraph, and Telephones Ministry, but in 1952 the telecommunications were separated and established as a self-supporting public agency under the Imperial Board of Telecommunications. This organization provides the country with telephone, telegraph, and broadcasting facilities. Between 1955 and 1959, the urban telephone traffic in Addis Ababa increased 3.3 times. During the same period, the interurban traffic in the whole of Ethiopia increased about 1.7 times, the number of outgoing international calls about doubled, and incoming international calls nearly tripled. In 1953, the number of telephone instruments in Ethiopia was slightly over 4,500, but at the end of 1959 there were about 11,000 telephones in the country.[1] Radio broadcasting stations provide the primary link with the outside world. The major towns throughout the country have post offices and airmail service available where regular stops are made by Ethiopian Airlines.

City traffic in Addis Ababa has increased tremendously, as will be noted from the fact that in 1961, 49 buses had to transport some 12 million passengers while traveling 2.2 million vehicle-kilometers. Streets are being widened preparatory to the introduction of trolley bus transportation. City traffic increased four times during the period 1957-1961.

1/From Ethiopian Trade Journal, December 1960.

19

TABLE VII-19 - PORT ASSAB TRAFFIC--1952-1960

Year	Entry of ships		Passengers (number)		Goods Turnover (metric tons)	
	No.	Net registered tonnage	Disembarked	Boarded	Goods loaded	Goods unloaded
1952	205	173,259	443	428	57,842	17,241
1953	286	327,382	380	242	49,256	21,952
1954	412	426,972	498	361	106,372	46,059
1955	396	493,419	378	250	89,331	49,333
1956	405	505,562	388	334	82,680	53,510
1957	504	576,647	390	501	98,327	70,461
1958	605	973,944	409	327	90,106	69,237
1959	552	956,079	532	453	94,301	76,857
1960	487	871,690	625	534	84,000	91,000

During the period 1963-1967, further development of transport and communications is expected to average about 7.1 percent annually. The rate of growth of transport and communications will therefore be about twice as large as the rate of development of the whole economy, which has been estimated at an average of four or five percent annually.

Road construction will continue so that new regions can be opened for development. In addition to the rehabilitation and betterment of existing railways, large-scale studies concerning the possible construction of new railway lines will be undertaken. Table VII-20 indicates the planned amount of investment during the period 1963-1967 for various segments of the transport and communications. In addition to completing about 409 kilometers of roads under construction in 1962, about 800 kilometers of new main roads and about 1,000 kilometers of feeder roads are forecast. Studies and designs will be initiated to expand the existing railway network to include links from Nazret to Dilla, from Agordat to Tessenei, and from Awash to Tendaho to Assab. Additional post offices will be opened throughout the country, and the postal services will introduce their own means of transportation.

Tourism. In 1960, a little less than 4,000 tourists visited Ethiopia, but during 1962 it was estimated that tourists arrived on the average of from 100 to 150 per week. Tourists are beginning to realize that Ethiopia has more relics than any other African country except Egypt and that the tourist season lasts practically the year around, as there are varieties of climate in the country. Even so, modern tourism is at the initial stage of development. Such advantages as pleasant climate, natural scenery, mineral hot springs, historical monuments, and hunting all offer great possibilities for the development of planned tourism. It is planned during the 1962-1967 period to open a number of tourist information centers in several foreign countries and to restore some of the historical monuments that have deteriorated in recent years, as well as to provide facilities in selected locations in the Empire to attract the attention of foreign tourists. Hotel accommodations are being expanded in Addis Ababa and in some outlying cities, such as Bahir Dar. In the Blue Nile River Basin, many opportunities are available for attracting tourists, but at present tourist activity is limited primarily to the Bahir Dar area near the Tis Isat Falls and to the Blue Nile gorge on the Addis Ababa-Debre Markos highway. A vast reservoir of natural game and scenic attractions exists in the upper Dabus Swamp area which could be developed into a veritable tourist paradise. The Ethiopian Tourist Organization was very recently established to facilitate the handling of tourists and the promotion of the tourist industry.

TABLE VII-20 - PLANNED INVESTMENTS IN THE PERIOD 1963-1967[1]

Branches of transportation and communication	1963-1967 (planned) thousands of Eth$	As percent of total	Index number, ratio $\frac{1963-1967}{1958-1962}$
Transportation:			
Railways	10,000	3.2	143
Roads	155,600	49.2	122
Water	24,163	7.6	90
Air	89,153	28.2	187
Subtotal	284,916	90.1	131
Communication:			
Posts	5,000	1.6	--
Telecommunications	26,500	8.3	265
Subtotal	31,500	9.9	315
Total	316,416	100.0	139

1/Second Five Year Development Plan.

In summary, tourism is only beginning to be developed but offers a potential of being a major industry in the acquisition of badly needed foreign exchange. To provide for tourism, modern facilities will be required which will develop a gradually increasing demand for electric power and energy to serve these facilities. For example, hotels will be needed, and construction of these alone by various interests during the period 1963-1967 is estimated to require approximately Eth$19,000,000, with most of this capital invested in Addis Ababa.

Income

The per capita annual income was estimated to have been Eth$89 in 1955 but by 1961 the per capita income was about Eth$97. Income in the rural areas, where some 90 percent of the population live, is much lower than for the urbanized areas. The large population of Addis Ababa, where the income is higher than in outlying areas of the country as a whole, brings the per capita income average up for the country. Per capita income during the period 1955-1961 increased at a rate of about 1.12 percent per year for the country as a whole. A sample survey of rural areas conducted in four general agricultural sections of the country gave these per capita estimates of income for the year 1960-61.

Ambo-Guder	Eth$40
Sululta-Chancho	65
Lekkemt-Sire	50
Bure-Jiga	37

It was found that in the rural areas about 4.7 people per family were the average, while in the urban areas the number of people per family was 3.7--in only one specific sample area surveyed.

The upward trend of future per capita income probably will not greatly exceed the 1.12 percent experienced in the period 1955-1961. The upward trend in the real capita income probably will lie between one and two percent per annum. By the year 2000, the per capita income may reach Eth$175 per year. The Eth$175 figure will be based upon a two percent per annum increase in real income. The gross national product, however, may increase at a rate of around four or five percent during the greater part of this period.

Employment and wages and salaries paid by the manufacturing industry in Ethiopia during 1961 are shown in Table VII-21.

TABLE VII-21 - EMPLOYMENT TOTALS, MANUFACTURING INDUSTRY, ALL ETHIOPIA--1961[1]

Industrial group	Total number of employees[3]	Annual wages and salaries paid (Eth$)[2]	
		Total	Average per employee
Foods (meats, grains, sugar, canning, edible oils, and byproducts)	10,031	6,412,000	631
Beverages (alcohol, beer, liquor, wine, soft drinks, and carbonated water)	1,194	1,143,000	999
Tobacco manufactures	436	406,000	931
Textiles (spinning, weaving, finishing, knitting, sacks, cordage, rope, and twine)	9,675	5,757,000	595
Footwear and leather tanning	990	905,000	914
Sawmills, planing mills, and plywood	1,458	569,000	390
Furniture and fixtures	627	449,000	716
Printing and publishing (excl. Berhanena Selam Printing Press in Addis Ababa)	465	504,000	1,083
Chemicals and chemical products (incl. oxygen, carbon dioxide, matches)	514	135,000	263
Nonmetallic mineral products (brick and cement)	1,039	1,107,000	846
Miscellaneous manufactures	1,615	483,000	300

1/Based upon data from Statistical Office, Ministry of Commerce and Industry, Addis Ababa.
2/About 75 percent located in Addis Ababa Complex.
3/Includes 4,600 nonfactory sugar cane and tomato plantation workers and some 400 forest woodcutters, but excludes some 5,000 women handpickers employed in the coffee cleaning industry.

Development of Electric Energy Use

The long-term economic development of the country will result in a constant increase in electric power requirements and will thus also require a long-term planning program for the development of electric power to keep pace with needs. The Second Five Year Development Plan recommends that priority be given to further expansion of the hydroelectric system of the Awash and Blue Nile Rivers and further recommends the preparation of studies for possible interconnection of individual systems, creating a larger interconnected complex.

Two broad fields of use have been forecast in Ethiopia--use for the requirements of the national economy and use by the population and municipalities. The national economy requirements would presumably include (1) commerce and industry, including government enterprise; and (2) transport and communication as well as irrigation and municipal water. The public consumption and illumination of towns would include (1) farm, residential (urban), and government buildings; (2) public streets and highway lighting; and (3) other sales to public authorities.

Based upon a forecast in the Second Five Year Development Plan, total production of electricity would be divided as shown in Table VII-22.

TABLE VII-22 - USE OF ELECTRIC POWER PRODUCTION BY SEGMENTS

Segment	1962 (%)	1967 (%)
National economy	42.5	58.5
Public consumption and illumination of towns	40.0	23.0
Transmission and distribution losses, plus plant use	17.5	18.5

From Table VII-22 it is apparent that emphasis is and will continue to be upon improving the national economy segment and, within this segment, development of commerce and industry will require the bulk of the electrical power and energy produced. More specifically, the Second Five Year Development Plan (July 7, 1962 to July 6, 1967)

2c

states that it is not possible to determine precisely the level of electric power production because production will depend upon completion of large industrial projects. However, the plan does define some instances where industrial development will occur.

During the period 1962-1967, government planners have scheduled an expenditure of Eth$353,400,000 for new industrial projects, while the remaining Eth$72,500,000 are to be used for completing projects under construction at the beginning of the 1962-1967 period and for the reconstruction of some existing factories. Out of 121 projects, 18 are being reconstructed or completed, and 103 new industrial projects are planned.

National Economy

No attemt is made in every instance to separate by individual load centers specifically the various commercial and industrial developments foreseen in the future as discussed in the ensuing paragraphs, although general consideration of these loads by location is made in the final load analysis presented in subsequent sections. Information as to specific locations for some of the proposed industrial plants was not obtainable, but it can generally be concluded that of those scheduled for the 13 provinces most of the load in this sector will fall within the Addis Ababa Complex.

Food Processing. Statistics are not available as to the amount of power and energy used in the food industry at the beginning of the Second Five Year Development Plan. Also, the specific capacity of every planned project was not always obtainable. However, it is known that 26 new food industrial processing projects are to be started and three existing plants reconstructed. The over-all rate of growth in this industry will be significant and will undoubtedly increase substantially with each successive five-year plan, as this industry will depend almost exclusively upon agriculture, which contributes 70 percent of the national income and employs 90 percent of the people.

Meat. The Second Five Year Development Plan forecasts the erection of several slaughterhouses in cattle raising regions and, after these establishments are placed in operation, the annual processing of more than 600,000 head of livestock. This would represent an increase of 600 percent in the production of processed meats by the end of 1967. The products of these new slaughterhouses will be frozen and canned meat intended primarily for export to foreign markets. To accomplish this, it will be necessary to fatten about 350,000 head of cattle and about 400,000 head of small livestock. This will be carried out by the large scale specialized farms which will be established during the period 1962-1967.

20

The total production of meat and meat products forecast in 1967, compared with 1957 and 1962, is as follows:

	Metric tons		
	1957	1962	1967
Meat (frozen)	683	5,500	35,000
Meat (canned)	1,290	1,000	7,000
Total	1,973	6,500	42,000

The source of livestock is no problem, because Ethiopia is classed among the countries of the world with the most numerous livestock in relation to the population. Disease control and measures for livestock improvement on a wide scale are planned by the Government.

To process 600,000 head of livestock per year (1967) would require about 18,000,000 kw.-hr. of energy with a maximum demand of about 6,000 kw., operated on a one eight-hour shift per day average. The power and energy requirement will, of course, depend upon the degree of electrification of the processing plants.

Although livestock is plentiful in certain areas of the Blue Nile River Basin, the bulk of the livestock is raised outside the basin, particularly to the south of Addis Ababa. Likely locations for processing plants are in Addis Ababa, Dire Dawa, Nazret, and Shashamane, all within the Addis Ababa Complex.

Dairy. Agriculture as a whole is expected to keep its pace of growth faster than the growth of population in order to supply adequate food for domestic consumption and more products for the processing industry and for export. One of those foods which is to be increased in quantity and quality is milk. Its main use will be to improve the diet of the population.

Provisions are made in the Second Five Year Development Plan for milk and dairy processing plants, but all locations were not obtainable. Plants totaling about 1,000 metric tons of annual capacity in Addis Ababa may possibly develop toward the end of the period. If this does, the annual energy requirement, 75,000 kw.-hr., would be very small, requiring a maximum demand of not more than about 50 kw.

Dairy products processing plants will develop more rapidly in the future, when the health conditions of cattle improve as a result of the control of livestock diseases and the improvement of quality through selective breeding.

Fruit and Vegetables. A small vegetable canning industry exists in Ethiopia, but vegetables are limited in the diet of people in many parts of Ethiopia. In order to improve the nutrition of the people, emphasis is being put on increasing the production of fruits and vegetables in the government's planning activities as evident in the Second Five Year Development Plan. For supplying the canning industry and larger towns, vegetable and fruit production is planned on a broader scale on large farms.

Present Ethiopian canned vegetable products are of good quality, and demand for them will undoubtedly increase in the future. During the next few years it is anticipated that at least one large fruit and vegetable canning plant may be established. A conservative annual energy requirement of 290,000 kw.-hr. with a maximum demand of 100 kw. is estimated by 1970, with increases after that date. This is based upon government planners' recommendations that during 1967 some 2,000 tons of quality fruit and vegetable products will be raised, largely on big farms.

The Ethiopian climate will permit growing certain varieties of fruit on a much greater scale than now. Very little of a fruit canning industry exists at this time. In a few locations, fruit is raised and sold in the larger towns. These fruits include citrus crops, bananas, grapes, papayas, peaches, and others.

Fish. The existing fishing industry is small and is generally limited to the Red Sea area, although fish are found in many of the inland lakes and could be developed into a thriving industry. With this in mind, the government planners have estimated that about 10,000 tons of fish products will be processed in the new plants to be erected on the Red Sea and on the lakes. In addition to supplying domestic needs, considerable quantities of fish products will be exported. Initially, the Red Sea fish processing plants will probably be established in Assab and Massawa. Each of these plants may require 250,000 kw.-hr. per year at about 80 kw. maximum demand. Initial production is estimated to begin during the period 1967-1970. Also, pending the results of studies of the inland lakes south of Mojo, it may be possible to erect a fish processing plant for drying and canning the better varieties of fish and processing the inferior varieties into fish meal and oil. This plant may require an investment of Eth$2,000,000, and for that size plant the initial energy requirement will be 250,000 kw.-hr. per year, with a maximum demand of 80 kw., and substantial increases are possible later.

Sugar. Sugar production in prior years, compared with the government planning goal in 1967, is as follows.

	Metric tons		
	1957	1962	1967
Sugar	16,181	38,000	60,000

In 1967, 60,000 tons of sugar cane will be produced. Sugar production in the past has not depended to any extent upon external electrical energy sources because processing plants have generally supplied their own energy. This was due partially to the lack of external electrical power sources. Also, the inherent nature of sugar processing requires steam, and a portion of this was utilized for conversion to electrical energy where required. However, government planners anticipate that during the period 1967 to 1972 a large sugar factory will be erected, the size of which has not been precisely determined. There is some indication that it might be capable of producing 30,000 tons of sugar per year, and on this basis the total annual energy requirement would be about 14,600,000 kw.-hr. with a maximum demand of about 4,000 kw. indicated. Part or all of this energy may be supplied from external sources. Sugar production will steadily increase in the future.

Confectionery. Practically all confectionery items are imported, but a small chocolate and candy factory is under way and others will undoubtedly follow because the major ingredients, sugar and oils (shortening), are available in Ethiopia. It is estimated that the first plant in Addis Ababa will require 135,000 kw.-hr. per year, having a maximum demand of 47 kw. This is but a modest beginning, and this industry will expand considerably in the future.

Oil Pressing and Margarine. The production of edible oils in Ethiopia during 1957 and 1962, as compared with the planning goal in 1967, is shown below.

	Metric tons		
	1957	1962	1967
Edible oil	4,350	4,800	12,000

The production of oil seeds will increase from 351,000 metric tons in 1961 to 424,000 metric tons in 1967, or an increase of 73,000 metric tons (20 percent). However, of the 73,000 tons, 40,000 will be used by existing and planned industries, including cottage and handicraft industries, by 1967. Conversion to edible oil will be in the amounts indicated above, which will require additional oil seed pressing mills. Construction of additional pressing mills is planned. Before 1970, it is likely that a 6,000-ton per year mill

29

to supply processed oil for a margarine plant, the first in Ethiopia, will be established in Addis Ababa. The annual energy requirement for such a mill will be quite small, something on the order of 290,000 kw.-hr. per year with a maximum demand of about 100 kw. This would be merely the forerunner of similar plants that may be established in the future with substantial energy requirements foreseen.

Beverages. This category includes the production of wines, liquors, alcohol, soft drinks, and tej, the latter a local, popular wine using honey as a base. Production, past and future, of principal beverage items is as follows.

	Hectoliters		
	1957	1962	1967
Beer	41,780	67,000	100,000
Wine	12,900	18,600	85,000-100,000

The government planners foresee an increased production in 1967 of 85,000 to 100,000 hectoliters of wine. Substantial increases in soft drinks, alcohol, and tej are also forecast. One new brewery will be established by 1967 to provide for the increase in beer production. Also, there is some indication that a small whiskey distillery may develop during this period. While annual energy and power requirements will initially be very small, these industries form the nucleus for the start of a promising industry in Ethiopia with substantial power requirements in the future.

Initially, the small distillery would not use much more than 60,000 kw.-hr. per year at a maximum demand of 20 kw. To increase the production of beer in the amount indicated by government planners, modern brewing principles would call for an annual energy requirement of 3,285,000 kw.-hr. with a maximum demand of 400 kw.

Miscellaneous. The production of certain other food items is to be stimulated, according to government planners, and this applies particularly to such items as flour, powdered coffee, macaroni, and eggs. Ethiopia had been an exporter of wheat until quite recently, when it began to import small quantities of wheat to provide for the needs of the increasing population. In 1957 and 1962, flour and macaroni were processed in the amounts shown below.

	Metric tons	
	1957	1962
Flour	23,000	24,000
Macaroni	2,700	2,800

For 1967, the goal is 51,000 tons of flour and 3,100 tons of macaroni, representing increases of over 100 percent for flour and about 10 percent for macaroni. Flour milling will require additional power and energy, with requirements for 1967 amounting to 3,100,000 kw.-hr. with a maximum demand of 700 kw. Some six flour mills are planned.

A new factory for the production of powdered coffee is to be constructed during the 1962-1967 period, to have an annual capacity of 3,000 tons; in the year 1967 it will produce 1,500 tons of powdered coffee for export.

Textiles and Wearing Apparel. The per capita consumption of cotton textiles in 1961 was estimated at 2.3 square meters, with the estimated consumption to reach 4.3 square meters (88-percent increase) by 1967. The consumption of cotton in 1967 will be 24,000 tons, according to government planners. In different terminology, the gross value of the total textile industry production in 1961 was Eth$39,000,000, and the gross value in 1967 is forecast at Eth$88,860,000, or an increase of 128 percent. The bulk of the textile industry production will therefore be in cotton textiles. The estimated production of cotton fabrics will increase from 21.5 million square meters in 1962 to 74 million square meters in 1967. A new rayon factory of 1,500-ton capacity is to be completed in 1964. The increased production of cotton and synthetic fabrics is intended to satisfy the domestic needs. Cottage industries will increase and will require cotton yarn, the production of which will be increased. Along with this, the manufacture of such final goods in the textile industry as blankets, hosiery, and knitted wear is also being planned.

A new woolen products factory is planned that will produce about 270,000 blankets a year in addition to other goods, thus reducing the need to import these items. Using basic domestic raw materials, primarily flax, another factory will be constructed to produce 500 tons of flax products (linen and oil) yearly. The erection of a factory to produce 100,000 umbrellas yearly will also be accomplished by the end of 1966. A factory for processing musa (a fiber plant) with an annual capacity of 1,000 tons is to be built by the same target date. The output from this factory will be added to other sources to increase production of sacks and rope from 2.8 to 6.0 million pieces, in part from another new factory having an annual capacity of 2,000 tons. The erection of a ready-to-wear clothes factory is also planned, which will supply the immediate needs of military and civilian demands.

In summary, there will be nine new textile factories developed by the end of 1967 with six existing ones completed or

reconstructed. This trend may continue in the future in order to provide the basic needs of the expanding population, and the requirement for electricity will thus increase greatly.

Existing leather and shoe factories, with tariff protection from external imports, will be able to produce about 1,000 tons of leather and 650,000 pairs of leather shoes in 1967. The erection of the new slaughterhouses will make available an increased quantity of hides and hence considerably increase the production of leather and shoes. Government planners expect to establish several new leather and shoe factories with a total capacity of 8,000 tons of leather and five million pairs of shoes to be produced. Production will exceed national demand, so export is contemplated. To meet the demand of the domestic market for low-priced footwear, the erection of a canvas and rubber shoe factory has been planned with a production of about 1,300,000 pairs in 1967. All told, one leather and shoe factory will be completed and eight new ones started by the end of 1967. By that year, 2,150,000 pairs of leather shoes will be produced annually.

Forestry Products. In 1962 about 12,500 cubic meters of lumber were produced from domestic timber, and this is expected to rise to 20,000 cubic meters by 1967. A new sawmill will be constructed, but it will not in all probability be driven by electric motors. In 1962, about 1,200 cubic meters of plywood were manufactured, and by the end of 1967, this is expected to increase to 3,000 cubic meters.

Increased production of furniture and other final wood products will occur as a result of the construction of a new furniture factory which is planned by 1965. Three new, wood products industrial projects are to be established by 1970, including the sawmill and furniture factory already noted, plus a new, 10,000-ton annual capacity mill.

There are good prospects for a substantial increase in production from this industry in the future as special emphasis will be placed upon afforestation and preservation of existing forests. During the period 1962-1967, feasibility studies using some existing forest products for paper pulp, tannin, and resin will be completed and, if prospects are favorable, industrial projects will be started.

Factories which are needed and will probably eventually be constructed include, in addition to those cited, plants specializing in the manufacture of cardboard boxes and paper containers and of prefabricated buildings.

20

The electrical power load requirements in this field alone will be significant as industrialization progresses, and these loads are included in the totals shown in subsequent charts and graphs.

Chemicals and Related Items. A chemical industry, as such, barely existed in Ethiopia as late as 1961. However, the discovery of some basic minerals and the domestic demand for chemicals now imported, have led government planners to forecast a very intensive development of the chemical industry, beginning with the period 1962-1967 and continuing into the future. The new capacities of this industry are to be based mainly upon domestic raw materials for the production of pulp for paper and viscose, caustic soda, sulphuric acid, carbon bisulfide, pharmaceutical products, soap, glass, leather tanning material, and others.

As Ethiopia is badly in need of a nucleus for a chemical industry, a logical site for early establishment of plants to provide the basis for the industry may be in the vicinity of Assab. (The only large oil refinery in Ethiopia will be located there.) Whether this will be the location finally selected is impossible to forecast; however, the availability of salt (sodium chloride) in abundance and the availability of sylvite and carnallite (potassium salts) as well as other salts in the Danakil area (vicinity of Dallol) will provide some of the raw materials. Production will be initiated at the rate of 300,000 tons per annum. This includes the building of a new, deep water port and a new, 97-kilometer (58-mile) road.

About 200,000 metric tons of salt are produced annually from sea water, and most of this is exported. About 20,000 tons of rock salt are also produced for the local markets.

Table VII-23 indicates the chemical plants which could be developed at Assab, assuming adequate electrical power at reasonable rates becomes available. (Assab may be the logical site because of a good road to the interior of Ethiopia and the proposed location of an oil refinery there. Adequate supplies of nonsaline water are questionable, however.)

25

TABLE VII-23 - CHEMICAL PLANTS POSSIBLE OF DEVELOPMENT NEAR ASSAB

Plant	Maximum demand (kw.)	Annual Energy requirement (kw.-hr.)
Caustic soda; and Salt electrolysis and chlorine	3,770	33,000,000
Sulphur extraction	60	470,000
Potassium fertilizer	195	800,000
Nitric acid and fertilizer	40	350,000

Large quantities of salt (NaCl) are available as rock salt in the Danakil area or from sea water by evaporation. Electrolysis of NaCl will produce caustic soda (NaOH), an essential basic chemical for a diversified industry. Chlorine and hydrogen are also released in this process. Chlorine can be liquified and transported. Hydrogen gas can be used to produce ammonia and hydrochloric acid, both essential industrial chemicals.

Fused salts at high temperatures, free from water, can also be decomposed. Fused salt is electrolyzed to produce metallic sodium at a very low cost to be used in the preparation of a number of other chemicals which could not otherwise be processed, including sodium peroxide and sodamide, essential for any chemical industry. A host of important derivatives of metallic sodium can be developed, only one of which is described here.

Sodamide is made by the action of dry ammonia on metallic sodium. It is used for the synthesis of indigo and in other organic reactions. When heated with carbon, sodamide is changed to sodium cyanide, in great demand for electroplating, in fumigation, in the extraction of gold, silver, zinc, and lead from ores, and in a mixture with sodium chloride and sodium carbonate for case-hardening of steel.

The direct synthetic ammonia process passes pure nitrogen and hydrogen over a catalyst under pressure and at high temperature. By catalytic oxidation, ammonia is easily changed into nitric acid and this in turn into nitrates (fertilizers).

Crude carnallite, such as is available around Dallol, can be refined to potassium chloride by treating the crushed ore with a hot solution of magnesium chloride. Two grades of potassium chloride (KCL), one for higher grade chemical uses and one for fertilizer, can be produced. Some sylvite is also available, as is potassium chloride (KCL) in a crude, natural state. These have important uses in making liquid and soft soaps, in photography and medicine, in explosives, and in glass making.

Chemically pure hydrochloric acid can be produced by burning electrolytically produced chlorine in excess hydrogen.

Magnesium chloride is available in a natural state 18 kilometers southwest of Dallol. Magnesium can be made by the electrolysis of fused anhydrous magnesium chloride in an electrolitic cell containing potassium chloride.

In the Dallol area, sulphur minerals have been found from which sulphur can be extracted. Its most important use is in the manufacture of sulphuric acid, essential to any chemical industry. It is also necessary for possible future industries, such as the manufacture of paper, matches, gunpowder, insecticides, fertilizers, and vulcanizing (rubber industry).

Thus, the five plants that have been described are all closely related and require only modest amounts of electricity, except for those using the electrolysis processes. The processes described are not all covered by the five plants listed, so other plants could be added when justified. If all processes mentioned were to be developed, the electrical energy requirement would easily triple, with the ultimate requirement depending upon the demand for the products.

In 1962 the gross value of production of the chemical industry was estimated at Eth$950,000 as contrasted with a forecast production in 1967 of Eth$36,100,000, or an increase of 38 times. To indicate the degree of emphasis being placed upon this industry, it was noted that government planners forecast a total investment of Eth$51,050,000 in this segment during the period 1963-1967 as compared with Eth$740,000 for the previous five-year period, or an increase of 690-fold.

According to government planners, the chemical industry will expand by 21 new plants during the period 1963-1967 (Table VII-13). Early emphasis seems to be directed toward supporting synthetic fiber plants and pulp mills with the necessary raw materials. Production of wood pulp will be initiated to support a new 8,500-ton capacity paper factory and a 12,000-ton viscose

210

factory. These factories will need chemicals, and to supply their needs a caustic soda factory (12,000 tons), a carbon bisulfide factory (6,000 tons), and a sulphuric acid factory (20,000 tons) will be required. Availability of domestic raw materials will justify the erection of a 6,000-ton soap factory. Two tanning material factories will be established, having a total annual output of 2,000 tons. Source of raw material is domestic trees, and the output from the factories will be used primarily in the domestic leather industry. Deposits of quartz sands will be used to increase the output of existing glass factories as well as a basis for erecting a new glass factory with an annual output of one million square meters. (In 1957 the output of glass bottles was 3,800,000; in 1962, 7,500,000; and in 1967, the forecast is 14,000,000 bottles, an increase of 1.87 times.)

All pharmaceutical products are imported, but during the period 1962-1967, government planners expect that a pharmaceutical factory will be constructed. In addition, a plastic product factory and a tire plant are to be constructed. Near 1966, a start will be made on one of these factories: fertilizer plant, paint plant, pharmaceutical plant No. 2, soap factory No. 2, lubricating oil plant (expansion of the then existing refinery), or PVC plant (polyvinyl chlorides).

By 1967 or shortly thereafter, the industrial power requirements will be significant and will be supplied primarily from hydroelectric sources. Some industrial plants, such as the sugar factories, may not initially depend upon electricity from an external source, but at present the most economical source of energy in Ethiopia is hydroelectric power and it probably will remain so in the future.

Although complete proposed production information for every factory is unknown at this time, an estimate of future power and energy requirements is included in the totals shown in subsequent charts and graphs.

Petroleum. There was no oil produced in Ethiopia in 1962, but oil exploration continued on the Red Sea coast, including the islands, with some favorable results obtained which would warrant a drilling program. In the eastern area of Ogaden, exploration by the Gewerkschaft Elwerath Oil Company continued with the results unknown in 1962. Construction planning has started on an oil refinery at Assab with a capacity to handle about 500,000 tons yearly. This will be increased (doubled) if domestic crude oil is discovered, and the addition of a lubricating oil plant is planned later.

2

The power requirements of the Assab refinery will be substantial, with a 2,000-kw. load and an annual requirement of more than 11,650,000 kw.-hr. Maximum development may require 5,000 kw. and 40,000,000 kw.-hr. annually.

Establishing the refinery at Assab would favor the location there of the chemical plants previously described.

Mineral Products

Mining. All mineral rights in the country are under the control of the Imperial Ethiopian Government, which operates two gold mines and a platinum mine. Concessions are granted by the Government on a profit-sharing basis, and perhaps two of the more important concessions granted in recent years are those to the Ralph M. Parsons Company and the Gewerkschaft Elwerath Oil Company (see "Petroleum"). The Ralph M. Parsons Company, a U.S. firm, has a concession to mine potash at Dallol, 95 kilometers (56 miles) south of the Red Sea port of Mersa Fatma. The concession was amended to include other minerals. Ore bodies of sylvite, carnallite, and other salts have been discovered, and production will be at the rate of 300,000 tons per annum.

The Societa Saline di Massaua and the Societe des Salines d'Assab each produce about 100,000 metric tons of salt annually from sea water.

A small amount of manganese ore is exported from a deposit at Enkefella, 18 kilometers southwest of Dallol.

If a proposed barter arrangement with Krupp Industries, West Germany, is consummated, 300,000 tons of 60-percent iron ore (hematite and magnetite) will be exported annually from Agometta, 30 kilometers southwest of Massawa.

Many other minerals have been found in Ethiopia, but most have not been in sufficient quantity to justify much commercial exploitation. These include copper, lead, mica, vermiculites, gypsum, alabaster, pumice, magnetite, phosphates, talc, graphite, and precious stones.

Predictions are that future electric power requirements in the mining industry will remain low but should show some increase by 1966. A small hydroelectric plant has been constructed by the IEG to serve one mining area, and until the interconnected transmission system is extended from its present location, this will be the pattern followed to meet future mining loads.

21

Cement and Cement Products. The Ethiopian Cement Corporation, a state-owned firm, quarries clay and Jurassic limestone at Dire Dawa to product portland cement. Production in 1959-1961 has been from 25,000 to 30,000 tons. A new cement factory was started in 1962 in Addis Ababa, capable of producing 70,000 metric tons of cement per year from limestone deposits discovered by U.S. Bureau of Reclamation geologists in the Muger canyon about 45 kilometers north of the city. The erection of another cement factory, costing about Eth$15,000,000 and probably located in the Massawa area, is foreseen in 1965. It would have an annual output of 150,000 metric tons, primarily for export. In addition, a new factory for asbestos-cement products will be established, probably in or near Addis Ababa. The estimated power and energy requirements are shown in Table VII-24.

TABLE VII-24. POWER AND ENERGY REQUIREMENTS FOR PROPOSED CEMENT FACTORIES

Plant	Place	Requirements	
		kw.	kw.-hr.
Cement (70,000 metric tons)	Addis Ababa	1,400	11,000,000
Cement (150,000 metric tons)	Massawa	2,500	20,000,000
Cement products	Addis Ababa	100	210,000

By 1967, the total output of cement plants will have reached 210,000 tons with the full production, probably 250,000 tons, of the three primary plants to be realized shortly thereafter. Long range plans also include a cement factory at Bahir Dar.

Bricks. In 1957, 5,670,000 bricks were produced, which increased to 8,000,000 in 1962. Total production is forecast to reach 30,000,000 by 1967. This will be accomplished by the erection of new brickyards, total capacity of which will be 20,000,000 bricks annually. Electric power requirements will be limited to motor loads, the main heat source being nonelectrical. During the period 1967-1970, it is planned to construct a refractory materials plant to meet the needs of the metallurgical and other industries. Modern technique requires the use of electric furnaces to produce high quality refractories, such as will be required for boiler linings and locomotives, open hearth steel furnaces, heat-treating furnaces, and the glass and ceramic industry.

Lime. Lime factories are proposed which will produce 5,000 metric tons annually. Suitable limestone deposits exist in many areas of the Empire. Electric power requirements will be for motor loads, and if a rotary kiln is used the amount of power required will be about 550,000 kw.-hr. per year (70 kw.) by the end of 1967, if the goals of the Second Five Year Development Plan are realized.

Porcelain. During the period 1967-1970, a porcelain factory will be established to manufacture porcelain items for electrical products, primarily insulators of all types and porcelain parts for switches, receptacles, and fixtures. The capacity of the factory has not been fixed. Kaolin clays have been located by USBR geologists in or near the Giamma canyon, not far from Addis Ababa. A tunnel kiln will probably be used, and fuel is generally oil, coal, gas, or even electricity. At present, Ethiopia would have to import these fuels, except for electricity. Considering the small plant required initially, electricity may be used and would require 4,000,000 kw.-hr. annually at 450 kw. for three-shift operation to produce 500 metric tons of porcelain products per year. A total of 13 new plants will be erected or started during the period 1962-1967, devoted to producing mineral products for the building and nonmetal industries.

Iron and Steel. Except for the iron ore deposit in Eritrea Province, a domestic commercial supply of iron ore was not known to exist in inland Ethiopia as of 1962, but government planners are confident that a comprehensive prospecting program will reveal iron ore deposits in the future; thus they are hopeful that before the end of the five-year period 1962-1967 a steel plant with a forecast capacity of 80,000 metric tons output will be built. This, together with the Akaki Iron Works, completed in 1962 with an annual output of about 20,000 metric tons (using scrap iron), should be sufficient to start a metal and electric products industry which will serve the basic needs of the country. On this basis, these plants may be erected by 1967:

Agricultural Machine and Tool Factory
Metal Processing Plant
Metal Construction Plant
Household Appliance Plant
Tractor and Motor Car Assembly Plant
Aluminumware Factory
Electro Installations Factory
Electric Light Bulb Factory

214

By 1967, the following additional plants may be started:

Metal Processing Plant No. 2
Shipyard
Electric Motor Factory
Electric Wire and Cable Factory
Ship Repair Plants
Automobile Battery Factory
Steel Mill (discussed above)

All told, 15 new factories will be completed or started by the end of 1967 in this particularly industrial segment, and all will have substantial electrical power and energy requirements which will steadily increase in the future. Maximum power and energy requirements for these 15 new factories, when completed, cannot be definitely determined at this time, as plant output was not established in all cases in 1962. However, using data available, the maximum requirements are estimated in Table VII-25.

Miscellaneous

Tobacco. In 1957, about 252,000,000 cigarettes were produced, and in 1962 this increased to 370,000,000 with the proposed production in 1967 to reach 500,000,000. This will be accomplished by constructing one additional factory, probably to be started very late in the plan. Small motor loads are anticipated.

Printing and Publishing. Existing plants are to be expanded and one new plant of larger capacity is to be constructed by 1967. Small motor and some minor heating loads will develop, perhaps 50 kw. and 450,000 kw.-hr.

Other (Transport and Communications). This sector of the economy includes railways, road transport, air transport, water transport, city traffic, postal system, and radio and telephone communication facilities. Electricity requirements for these facilities up to this time have been limited to control of city traffic, airports, harbors, and the radio-telephone communication facilities and, in total, have been rather modest.

A ship repair plant at either Massawa or Assab is likely with the gradual development of the Imperial Ethiopian Navy. An estimate of annual energy requirements is about 470,000 kw.-hr. with a maximum demand of 225 kw., using a one shift per day operation.

The Addis Ababa International Airport, going into initial operation in 1963, will have a demand of 800 kw. and will require

215

TABLE VII-25 - ESTIMATED POWER REQUIREMENTS FOR FACTORIES PLANNED BY 1967

Plant	kw.-hr.	Maximum kw. demand
Steel Plant, 80,000 tons	32,000,000	3,650
Agricultural Machine Tool Factory	845,000	300 1/
Metal Processing Plant	4,000,000	600 2/
Metal Construction Plant	260,000	40 3/
Household Appliance Plant	260,000	90 4/
Tractor Assembly Plant	580,000	225 5/
Ship Repair Plants	1,000,000	450 6/
Aluminumware Factory	200,000	75 7/
Automobile Battery Factory	200,000	65 8/
Electro Installations Factory	200,000	65
Electric Light Bulb Factory	200,000	65
Metal Processing Plant No. 2	8,000,000	1,200 9/
Shipyard	6,000,000	750
Electric Motor Factory	440,000	150 10/
Electric Wire and Cable Factory	600,000	375 11/

Estimated Capacities:

1/Output 2,500 tons, 3 shifts.
2/Rolling mill, 18,000 tons, 3 shifts.
3/Structural steel, 600 tons, 3 shifts.
4/Iron cooking utensils, 400,000 pieces annually, 120 hp., one shift.
5/Eth$2,000,000 investment assumed, 1 shift.
6/Two plants (Massawa and Assab), 1 shift.
7/Aluminum cooking utensils, 300,000 items annually, 1 shift.
8/Annually 12,000 units, using 4,000 gallons oil per year in addition.
9/Rolling mill, 36,000 tons.
10/Annually 3,000 motors of 1/6 to 10 hp., 200 hp. connected load.
11/Copper wire, 120 tons annually, 500 hp. connected load.

2

about 3,500,000 kw.-hr. annually. The new LWF radio station will require 600 kw. and 2,500,000 kw.-hr. annually and will begin full scale broadcasts in 1963. I.B.T.E. radio station will require 600 kw. and 2,500,000 kw.-hr. and will begin broadcasting during the period 1963-1967.

The rate of growth of this sector is forecast to average over seven percent annually during the period 1962-1967, as compared with the total economy increase of four or five percent. The emphasis of this sector is in anticipation of the expanded industrial production, volume of trade, and marketable agricultural products.

The present railway transport is carried by two narrow-gage railroads--the Djibouti-Addis Ababa railway and the Massawa-Asmara-Agordat railway in Eritrea, both of which have been discussed in an earlier section. Government planners during the period 1962-1967 will prepare studies and designs to construct new railraods--Nazret-Dilla, Agordat-Tessenei, and Awash-Tendaho-Assab. Railway electrification requires a high traffic density in order to justify the installation, as the initial investment required is high. Therefore, the immediate prospects for electrification are very unlikely. However, from the long range viewpoint, electrification of some road sections is a possibility. This will be particularly true if the major source of energy in the Empire continues to be water power. The Awash-Tendaho-Assab road may become a principal transportation artery in the Empire and may eventually be electrified.

In Addis Ababa, planners have made a study of the city traffic problem with the recommendation that trolley bus transportation in combination with autobus be installed, and this project would be initiated in the period 1963-1967. The trolley buses would be driven by electric motors, and this selection was made on the basis of the configuration of the terrain in the city and an abundance of electric power, as well as the growing demand for city transport. The introduction of trolley buses was thus justified on economic grounds by the planners. Specific data are not available as to the number of trolley buses to be placed in operation, but estimates can be made based upon several factors, including the number of autobuses now being used. A substantial amount of electric energy will be required.

Emphasis is being placed upon lake and river transportation. In 1962, the only water transport was on Lake Tana and on the Baro River and that only partially developed. Inland water transportation facilities are to be expanded in the future with special emphasis placed upon Lake Tana to provide for the rapid development of Bahir Dar and other settlements along the lake. Opening of traffic on Lake Abaya (Lake Margharita) is planned in

21

connection with the fishing industry scheduled there. Electric power needs will be limited to navigation (lighthouses), dockside, and maintenance requirements and will be very modest for several years.

The expansion of the postal system and telecommunications facilities will not require substantial amounts of electricity, since it will be limited to the needs of the new buildings required, with minor amounts for the telephone system.

Domestic airports throughout the Empire are to be improved to accommodate all types of propeller-driven and small jet aircraft. With two or three exceptions, the domestic airports in 1962 were mainly grass strips to accommodate DC-3 or C-47 cargo planes. Government planners foresee an improvement of these airport facilities, and it is not unlikely that many within the next 15 or 20 years will have modern facilities, including night lighting. Demand should reach 2,000 kw. and energy requirements approach 9,000,000 kw.-hr. per year.

Public Consumption and Illumination

The south Eritrea load area, except for Assab, is sparsely settled, and there will be a negligible amount of energy sold in rural areas. Residential load for Assab will increase when and if a small industrial complex becomes firmly established around that town. The industrial load will become noticeable beginning in 1965 with the initial production from the Assab oil refinery and will become prominent by 1975 if the nucleus of a chemical industry is developed there. Also, the tourist industry in Ethiopia will develop in the future, and Assab will share in this, thus affecting power loads. The pleasant beaches, warm water, and continual ocean breeze will offset to some degree the high summertime temperatures.

A good estimate of Assab's population is not available, but a figure of 9,000 (1962) has been given. Considering the population increase that should result from increased port activities and a newly established petro-chemical industry, the loads have been estimated as shown in Table VII-47 (see "Estimated Future Need for Additional Generator Capacity--1964-1967").

The Addis Ababa load center complex contains the heart of the Ethiopian industrial empire. It is here that present industrial developments are concentrated and probably most future development will be here also. Because of its size and political importance, Addis Ababa has good prospects for continued growth in population and as a source of labor for industry.

This is the main electrical load center and far exceeds anything else in the country. The 450,000 population of Addis Ababa

in 1962 compares with the next largest city of Asmara, which has an estimated population of 100,000. These two probably will not be served from a common, interconnected, electrical system in the foreseeable future.

Addis Ababa has the bulk of the foreign population, whose per capita use of electricity will range from 50 to 250 kilowatt-hours per month, making use of all types of electrical appliances.

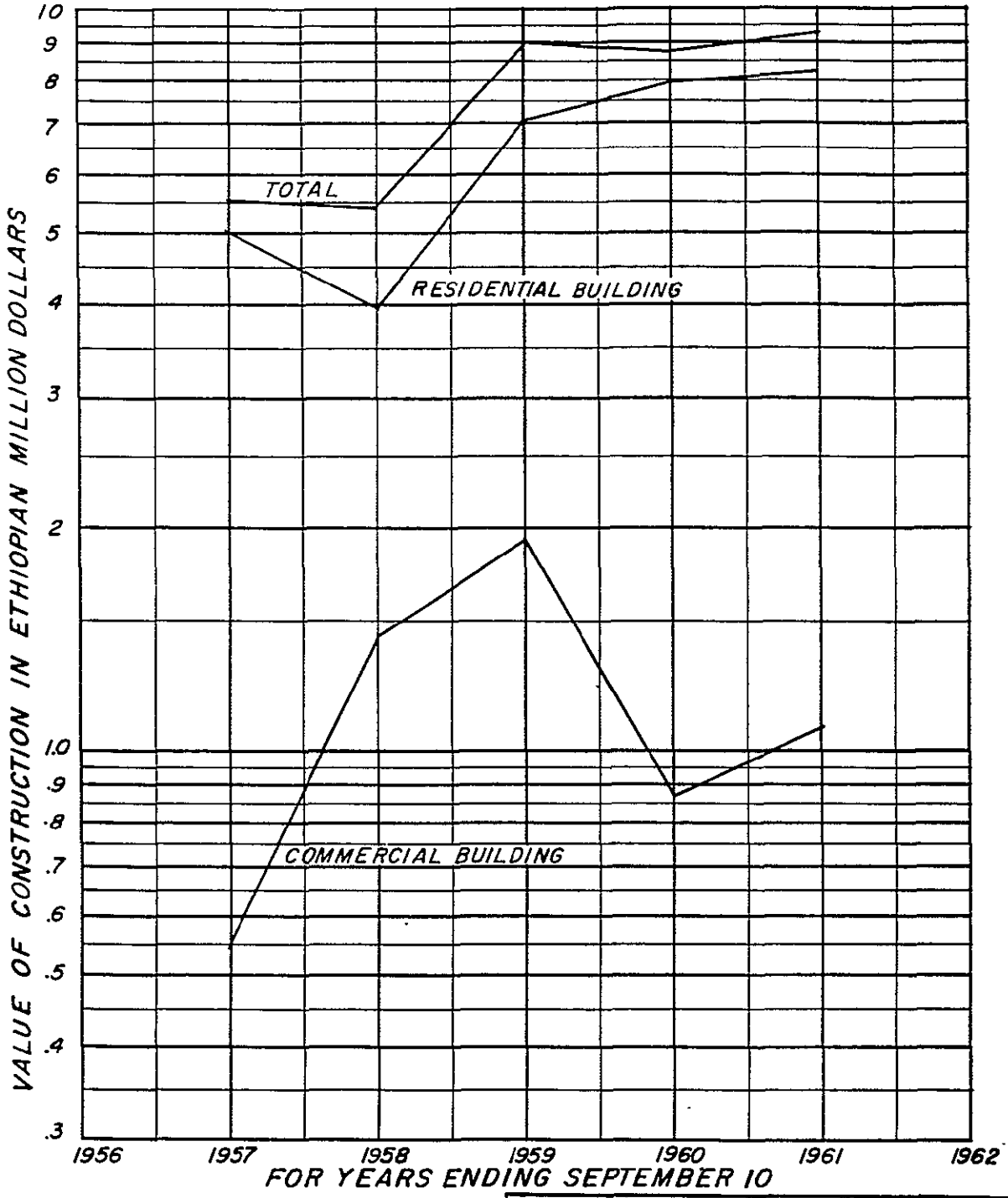
Institutions of higher learning established in Addis Ababa continue to attract young people, and the continued migration of people from the traditional agricultural areas to this city indicates that the population will experience a continued and substantial growth in the future. This, along with the per capita income in Addis Ababa (higher than that of the rest of the country), will mean a continuing increase in demand for electrical power to serve residential areas and also to supply the needs of many government buildings. Residential building construction has developed at a very rapid rate in comparison to commercial building construction. In 1961, nearly 90 percent of the construction was for residential needs, as shown by Drawing No. 4.0-BN-35.

An ambitious program of street and highway illumination in this area has greatly increased the demand for electricity for this purpose, but the total energy used is not separated from other use categories.

Sales of electricity to farms are negligible. Most farms are subsistence type enterprises with a very few devoted to truck farming, supplying vegetables to the Addis Ababa markets which in turn sell most of this to the foreign population. Plantation type operations afford little opportunity for electrical service now, but in the future may offer a possible outlet for power generated by Blue Nile River Basin powerplants.

Combined annual use of electricity by residential and government buildings and by public street lighting and other public authorities (schools) should develop in the future as shown on Table VII-35 (see "Losses").

Other provincial load areas in or adjacent to the Blue Nile River Basin under Case B include Dessie, Lekkemt, Jima, and Agere Hiywet (Ambo). Some of these areas have been mentioned as possible sites for certain types of industrial establishments. For the most part, with the possible exception of Dessie, these areas will depend almost entirely upon the surrounding agricultural economy. The future potential demands for electricity for rural



NOTES

1. Data not avilable for other lacotions but probably it presents 80% of construction in the Empire including Eritrea
2. Source: Municipality of Addis Ababa

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST. AGENCY FOR INT. DEV. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN
ELECTRIC POWER LOAD ANALYSIS
BUILDING CONSTRUCTION
ADDIS ABABA

DRAWN. C.L. CURTIS SUBMITTED. C.L.C.
TRACED. MASRESHA RECOMMENDED. P. W.K.
CHECKED. C.L.C. - G.V.J. APPROVED. C.E.B.

Addis Ababa Ethiopia MAY 30, 1962 4.0-BN-35

use adjacent to these centers will be very limited and will be used only by plantation type farms, if they should develop.

The potential demand for electricity in the public consumption and illumination category will be limited to residential and government buildings and to public streets and security lighting. As the standard of living is raised, the demand for electricity by the residents of these towns will increase but initially will be limited primarily to lighting loads. Sales to public authorities, such as schools, will also increase as more schools are introduced in these outlying areas. The nature of the loads will result in a generally low annual load factor, even in the foreseeable future. A breakdown of loads by classifications follows in a subsequent section.

Present Electric Rates

Generally, Ethiopia can be divided into two principal electric rates areas. The largest is the 13 provinces and the southern part of Eritrea, served principally by the Ethiopian Electric Light and Power Authority (EELPA). The other is the north Eritrea section, served principally by the Societa' Elettrica Dell' Africa Orientale (SEDAO).

The Blue Nile River Basin and adjacent areas fall within the marketing area of the EELPA, and as such the rate schedule of that authority will be of primary interest. Electric rates recently underwent a substantial reduction with the advent of the Koka Project hydroelectric power, which made a large block of more economical hydroelectric energy available for the first time in Ethiopia. Several small thermal and hydro units are operated in and adjacent to the Blue Nile River Basin. The reduction in rate throughout the area served by the EELPA resulted in subsidizing the higher unit cost of power generated at some of the smaller thermal and hydro units. In this way, the lower rates throughout the system encouraged greater use of electricity, and sales of electricity have increased greatly with the advent of the Koka power. As shown by Table VII-26, the present rates (1962) call for 15 cents per kilowatt-hour for the first 100 kilowatt-hours per month and 10 cents per kilowatt-hour for all use in excess of that during the same period. This is for the General Tariff classification, which includes residential service.

Cost of Electricity and Other Energy Sources

The cost of electricity can be considered in three general categories: (1) Large hydroelectric installations (Koka);

27

TABLE VII-26 - TARIFF IN FORCE, ETHIOPIA ELECTRIC LIGHT AND POWER AUTHORITY

Tariff classification	Sales price
General tariff:	
For the first 100 kw.-hr. per month	15 cents/kw.-hr.
For all consumption exceeding 100 kw.-hr. per month	10 cents/kw.-hr.
Commercial and industrial tariff:	
Fixed charge per kw. of maximum demand per month given by the maximum demand meter	Eth$5.00
For the first 1,000 kw.-hr. per month	10 cents/kw.-hr.
For all consumption over 1,000 kw.-hr. per month	5 cents/kw.-hr.
Off-peak tariff:	
For all off-peak energy	5 cents/kw.-hr.
Service charge:	
Single-phase per month	Eth$1.00
Three-phase per month	Eth$5.00

Special tariff:

Range of monthly kw.-hr. consumption	Percent reduction on total price	
	Normal consumers	Off-peak non-seasonal consumers
100,000-400,000	5	10
400,000-700,000	10	20
700,000-1,000,000	15	30
above 1,000,000	20	40

Note: Consumers under off-peak tariff have to sign special agreement with the EELPA, and each single case will have to be considered prior to approval.

2

(2) steam-electric generation (Addis Ababa); and (3) small isolated thermal installation (Bahir Dar).1/

(1) "By imposing an interest of 5 percent on the capital to be used for construction of the project, and amortization over 30 years for machinery, etc., and over 50 years for civil structures, and by calculating normal maintenance costs, the price for electricity produced at Koka and delivered in Addis Ababa and Dire Dawa will be about 2.15 cents per kw.-hr., provided an average of about 110 million kw.-hr. are delivered per year." Koka Hydroelectric Project, Imperial Ethiopian Government, December 1958.

(2) The Addis Ababa steam plant has a generator output of 5,000 kw. at site and has a maximum energy production of about 21,900,000 kw.-hr. with a load factor of about 50 percent.

The specific production costs at the plant vary from about 5.6 cents per kw.-hr. for full production to almost 11 cents for one-quarter production, as indicated by Table VII-27.

TABLE VII-27 - SPECIFIC PRODUCTION COSTS, ADDIS ABABA STEAM PLANT

Million kw.-hr./yr	In Ethiopian cents per kilowatt-hour					
	Fuel	Lub. oil	Per-sonnel	Mainten-ance	Deprecia-tion	Total
5.0	7.68	0.012	1.20	0.60	1.448	10.940
10.0	6.53	0.006	0.60	0.30	0.724	8.160
15.0	5.63	0.005	0.40	0.20	0.483	6.718
20.0	5.10	0.004	0.30	0.15	0.362	5.916
21.9	4.85	0.003	0.27	0.14	0.330	5.593

(3) The Bahir Dar diesel electric plant is typical of a small thermal plant serving a village area, and the total output of the station at the site is rated at 96 kw. with a load factor of about 40 percent. The maximum energy to be produced per year is about 336,000 kw.-hr. It was noted that the production cost per kw.-hr. ranged from almost 14 cents at full plant output to about 41 cents per kw.-hr. when loaded to about one-seventh of its maximum.

1/ Dessie and Jima costs would be slightly less.

22

Other energy sources include firewood, charcoal, petroleum products, and coal. Coal is an insignificant part of the total fuel sources used and can be neglected as a source of energy. An indication of the use made of different types of energy sources, by industry, can be obtained by comparing the costs of energy used by various segments of industry, as shown on Table VII-28.

TABLE VII-28 - COMPARISON OF ENERGY COSTS IN 1958
BY SEGMENTS OF INDUSTRY

Energy	Costs
Electricity from public utility services	Eth$1,146,000
Petroleum products	2,030,000
Charcoal	239,000
Firewood	239,000
Total	Eth$3,714,000

Fuel oil used to fire the boilers of the Addis Ababa steam plant cost Eth$128 per metric ton, f.o.b. Addis Ababa, while diesel oil delivered to Bahir Dar for operating the diesel electric plants there cost Eth$308 per metric ton, f.o.b. Bahir Dar. The Eth$299,000 expenditure for firewood was for the purchase of some 50,000 cubic meters, which would represent a cost of about Eth$6.00 per cubic meter. This was purchased by the manufacturing industries in 1958. During the same year, 4,000 metric tons of charcoal were purchased for Eth$239,000, representing some Eth$60 per ton. In 1958, the manufacturing industries used some 6,018 metric tons of petroleum products, consisting mainly of diesel and furnace oils, and this was valued at Eth$1,343,000. This was used mainly for generation of electric power for industry's own use. On the average then, this would have cost Eth$223 per metric ton. The Eth$6.00 per metric ton for firewood, as quoted from one source and as noted above, appears to be very low. Large quantities of firewood purchased by the USAID Mission in 1962 were about Eth$9.50 per cubic meter. This was in Addis Ababa. In other locations, such as Dire Dawa and Harar, Eth$2.90 per 100 kilograms was quoted,

221

which would amount to around Eth$14 per cubic meter. This, however, is for smaller lots. In a five-year period, 1958-1962, the cost of wood has increased 1.6 times in the Addis Ababa area.

The following Table VII-29 indicates that the most economical fuels are wood, charcoal, furnace oil, and diesel oil in the order indicated.

TABLE VII-29 - ENERGY COST OTHER THAN ELECTRICITY

Fuel	B.t.u./kg.	Cost Eth¢/kg.	B.t.u. for 1¢ (Eth)
Wood	15,400	2.9	5,310
Charcoal	28,160	6.0	4,693
Furnace oil	40,700	12.8	3,180
Diesel oil	41,250	30.8	1,340

The average cost of electricity from the utility serving the central provinces in 1962 was about eight cents per kw.-hr. (one kw.-hr. equals 3,413 B.t.u.). The number of B.t.u. per Ethiopian cent was 427. This, of course, is not in any way comparable with the last column in Table VII-29, as the conversion factors for combustion efficiency, handling costs, and other expenses associated with a commercial plant handling these fuels have all been omitted. Assuming the use of furnace oil for a steam-electric generating plant, and diesel oil in a diesel-electric plant, it was found that for a small type installation the cost of generating one kw.-hr. using furnace oil fuel, was Eth9.2¢, and the cost per kw.-hr. using diesel oil was Eth10.4¢. For a large hypothetical oil-fired steam-electric generating plant located near Akaki, the cost of production is slightly less than Eth5¢ per kw.-hr.

Diesel and furnace oils are imported items, whereas wood and charcoal are available locally. With the increasing demand, however, cost of local fuel has increased correspondingly over the past five years, with no indication that this trend will be changed. Generally, electricity, even at the present rates, is competitive with other forms of energy when considered from the industrial viewpoint. For domestic use, the low income groups will find wood and charcoal more economical than electricity for some time to come, although this will gradually change with time as the rates are lowered and the per capita income raised. For those in the higher income category, the other alternative to electricity is

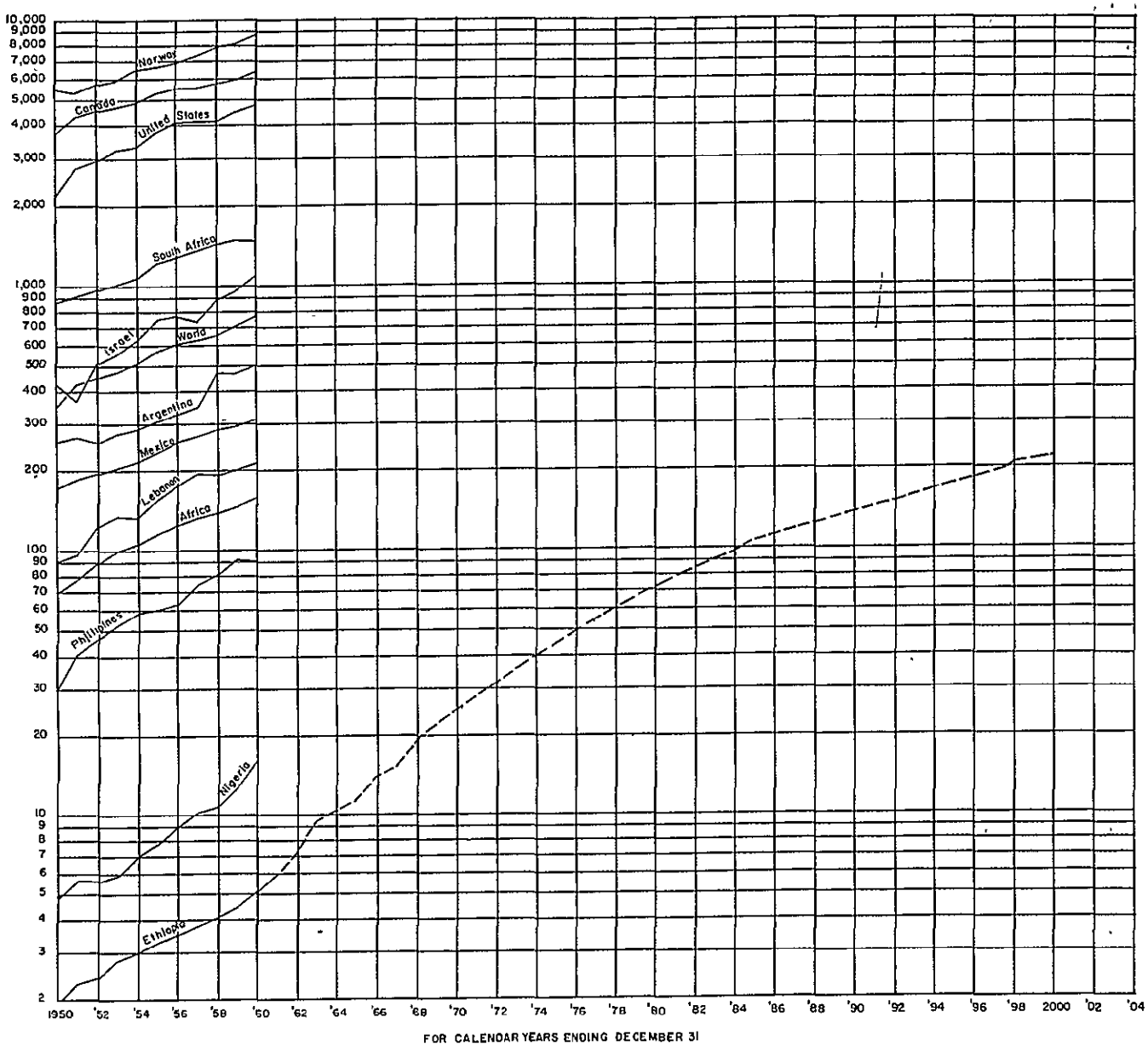
bottled gas; and, in this comparison, electricity at present rates is competitive with gas for residential and small commercial purposes.

Firewood is not always available. Charcoal is shipped into those areas where wood is not readily available, and the price varies considerably, being directly influenced by transportation costs. Fuel oil and diesel oil and related petroleum products have prices influenced by transportation costs that vary in different parts of the Empire.

A high percentage of the village and rural population depends upon cow dung for domestic fuel requirements. If this type of fuel were not available, the demand for charcoal and wood would greatly increase, driving the price upward practically out of reach of the lower income groups. As living standards and per capita income increase in the future, the lower income village and rural groups will turn to other traditional fuels, such as petroleum products, wood and charcoal, and electricity. The prices of wood and charcoal will continue to increase in the future, but the cost of electricity should actually decrease. The world trend in use and price of petroleum products has had a tendency to rise, partly because these products are a convenient taxation vehicle. Therefore, the conclusion is reached that electricity from hydroelectric sources offers the most stable, long-range energy source, both as to supply and as to price.

Past, Present, and Estimated Future Power Requirements

An insight into the magnitude and degree of electrification of a country is helpful when considering some aspect of the power supply problem. Ethiopia has about the lowest per capita electrical energy production in Africa--about 3 kw.-hr. per capita in 1954. In 1961 this had doubled to about 6 kw.-hr. and by 1965 should again double to about 12 kw.-hr. This corresponded to something over 100 kw.-hr. per capita for Africa as a whole in 1954 and about 500 kw.-hr. per capita for the world. In 1961 Africa produced 157 kw.-hr. per capita, and the world average was 766 kw.-hr. Drawing No. 4.0-BN-79 illustrates this trend and shows the production for Ethiopia increasing over 11 times to around 70 kw.-hr. per capita by 1980. Drawing No. 4.0-BN-151 shows the world power data for 1961 for the more advanced countries, led by Norway, Canada, Sweden, and the United States in that order.



1960
POPULATION ESTIMATES

Lebanon	1,646,000
Israel	2,114,000
Norway	3,587,000
South Africa	15,841,000
Canada	17,914,000
Ethiopia	19,950,000
Argentina	20,956,000
Philippines	27,456,000
Nigeria	34,296,000
Mexico	34,626,000
United States	180,670,000
Africa	254,000,000
World	2,995,000,000

LEGEND

——— *Per capita historical electrical energy production*

– – – – *Forecast of per capita electrical energy production requirements in Ethiopia based on studies of loads and population estimates.*

ETHIOPIA UNITED STATES COOPERATIVE PROGRAM
FOR THE
STUDY OF WATER RESOURCES
IN COLLABORATION WITH
U.S. DEPT. OF STATE AGENCY FOR INT'L DEVELOPMENT AND U.S. DEPT. OF INTERIOR BUREAU OF RECLAMATION

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN

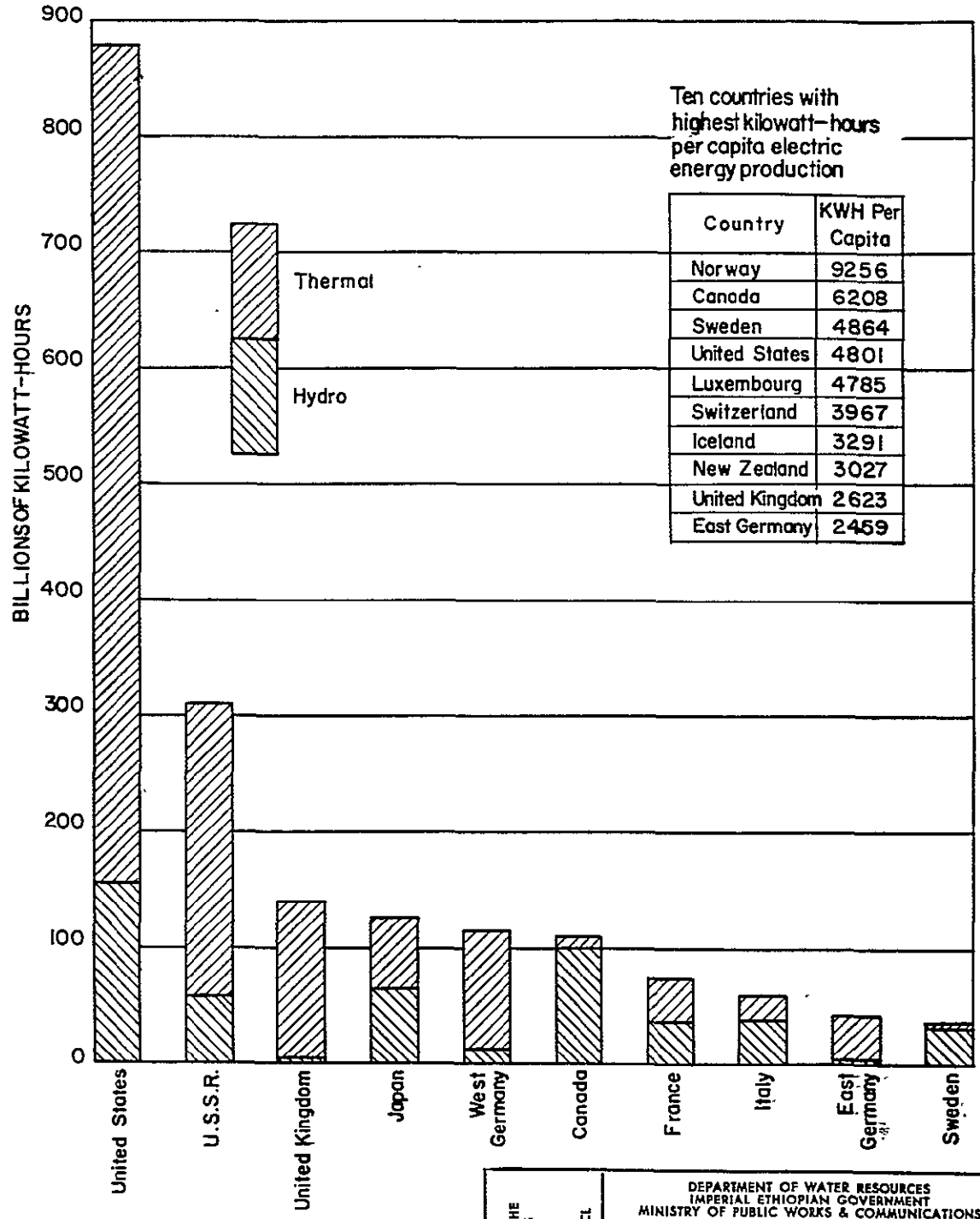
ELECTRIC POWER LOAD ANALYSIS

ESTIMATED FUTURE PER CAPITA ELECTRICAL ENERGY PRODUCTION REQUIREMENTS IN ETHIOPIA

DRAWN C L C
TRACED A M M
CHECKED C.L.C., C.L.C., G.E.J.
SUBMITTED C L C
RECOMMENDED P W K
APPROVED C E B.

Addis Ababa Ethiopia DEC 28, 1962

4 O-BN-79



Ten countries with highest kilowatt-hours per capita electric energy production

Country	KWH Per Capita
Norway	9256
Canada	6208
Sweden	4864
United States	4801
Luxembourg	4785
Switzerland	3967
Iceland	3291
New Zealand	3027
United Kingdom	2623
East Germany	2459

SOURCE: ELECTRICAL WORLD

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., A.I.D. AND U.S. DEPT. OF INT., BUR. OF RECL

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

WORLD POWER DATA — 1961

DRAWN G. V. J. SUBMITTED C. L. C.
TRACED A. N. M. RECOMMENDED P. W. K.
CHECKED C. L. C. APPROVED C. E. B.

Addis Ababa Ethiopia May 3, 1963 | 4.0-BN-151

System Conditions Considered for this Study

The heart of Ethiopia's industry--its main load area--is the Addis Ababa Complex (63.9 percent of total national production for load in 1962). This is the fastest growing area, where the supplier may be hard pressed to construct new facilities rapidly enough to meet the growing load demand. The Finchaa Sub-Basin potential hydroelectric facilities are conveniently located adjacent to this load area and can be considered as potential production facilities to meet future load requirements.

In this study, two conditions are considered--Case A and Case B--with the first condition, Case A, considering that there will be no major interconnections during the period of review, and with Case B assuming interconnections as follows:

1974: Lekkemt
Agere Hiywet (Ambo)
Jima

1977: Dessie
Assab

This particular study extends through 1980.

Existing Power Systems

Powerplants. The present interconnected system (Addis Ababa Complex) has five powerplants, some of which are maintained as reserve capacity as noted from Table VII-30. The 1961 (existing) Interconnected System serving the Addis Ababa Complex is as shown by Drawing No. 4.0-Et-13.1/

By far the greatest source of energy at present is Koka hydro which is served by a reservoir on the Awash River having a capacity of 1,500 million cu. m. Utilizing a head of 32 to 40 meters, the installed capacity consists of three generators, each rated at 18,000 kv.-a., or 54,000 kv.-a. total. The rated capacity at full load is 45 mw., but this includes one generator as a "spare." At the lowest reservoir level, the firm plant capacity, based upon two units, is regarded as 23 mw. as noted in Table VII-30. Koka powerplant may also be considered as "Awash No. 1." Drawing No. 4.0-BN-170 shows the Koka location.

1/Unchanged in 1963 except for loads.

TABLE VII-30 - 1961 INTERCONNECTED SYSTEM--ADDIS ABABA COMPLEX (CASES A AND B)1/

Name and type	Installed capacity (kv.-a)	Firm capacity (kw.)	Production capability (millions of kw.-hr.)		
			Good water years	Average water years	Adverse water years
Koka Hydro	54,000	23,000	120	110	90
Aba Samuel Hydro	8,250	4,750	27	23	18
Ourso Hydro	525	250	2	2	2
Addis Ababa Steam2/	6,250	(5,000)	0	10	30
Alemaya Diesel2/	2,910	2,000	1	5	10
Total	71,935	30,000	150	150	150

1/ Based upon January 1962 "Report--Past Activities and Future Programme," EELPA.

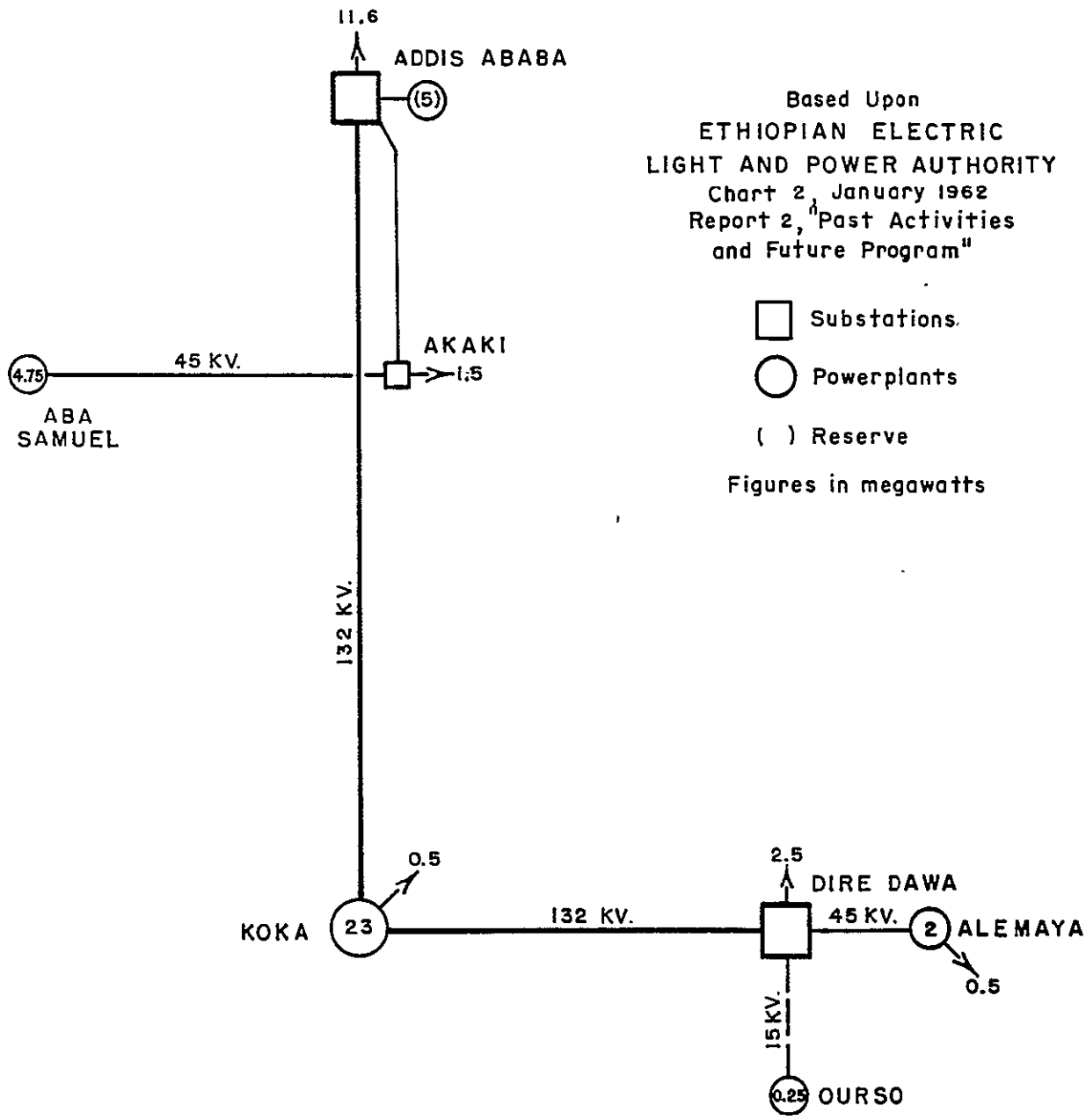
2/ Normally maintained as reserves in good water years; possible operation as shown in average and adverse water years.

Aba Samuel hydroelectric powerplant is about 35 km. south of Addis Ababa on the Acachi (Akaki) River, a tributary to the Awash. This was initially installed during the Italian Occupation in 1939. There are five generating units operating at 95 meters head (different sizes) providing a total rated capacity of 8,250 kv-a. or 6,600 kw. The reservoir has a storage capability of 60 million cu.m. Firm capability has been established as 4,750 kw.

The Ourso hydroelectric powerplant is 30 km. west of Dire Dawa and is served from a natural spring with no reservoir, having only forebay storage for a little regulation. It is rated at 525 kv.-a. with a head of 175 meters.

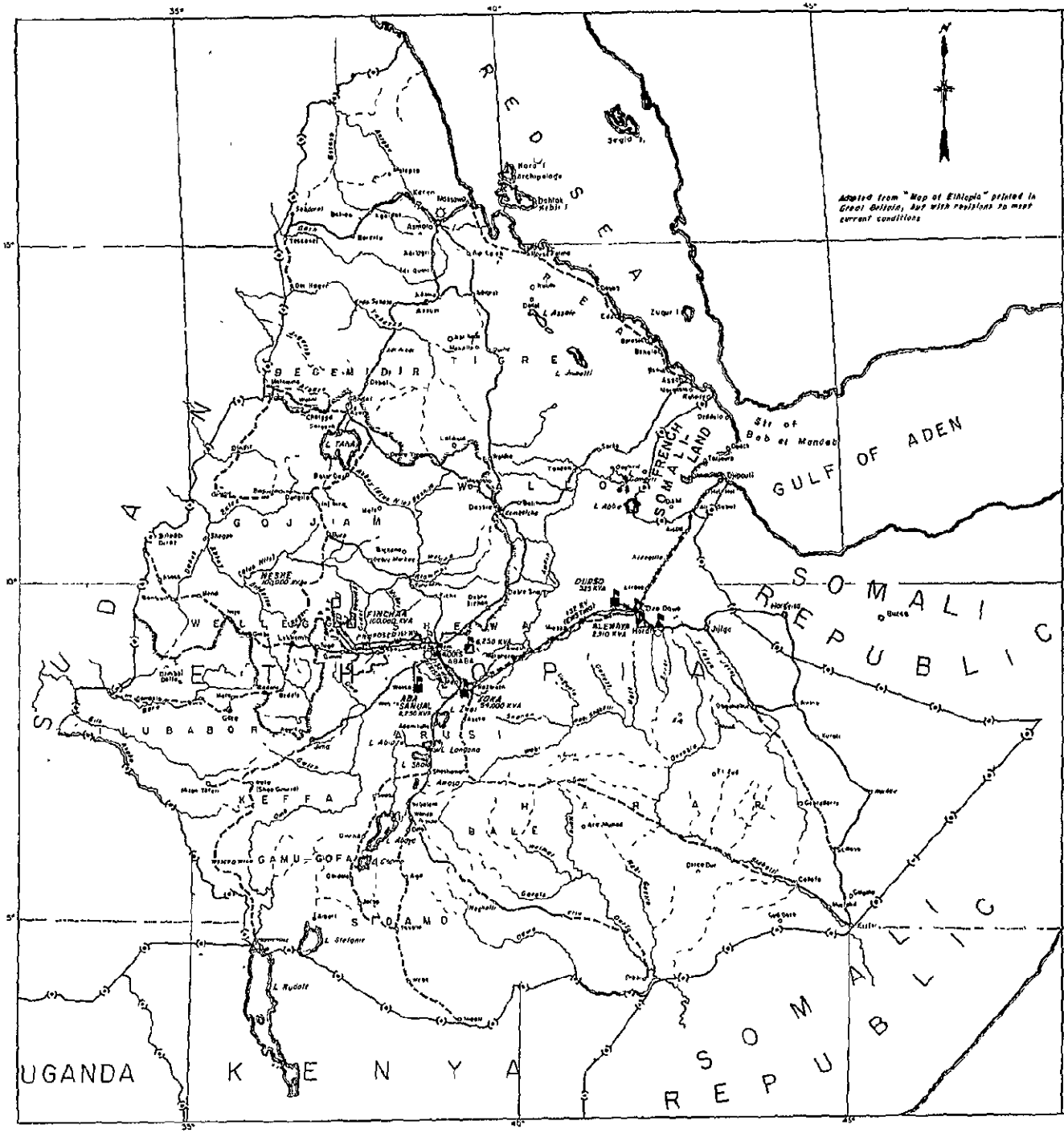
The Addis Ababa steam powerplant consists of one condensing steam turbine operating at a pressure of 29 kg. per sq. cm. at 425° C. and one 6,250-kv.-a. generator. It went into initial operation in 1957 and has been in standby since the early or middle part of 1960 with the advent of Koka power.

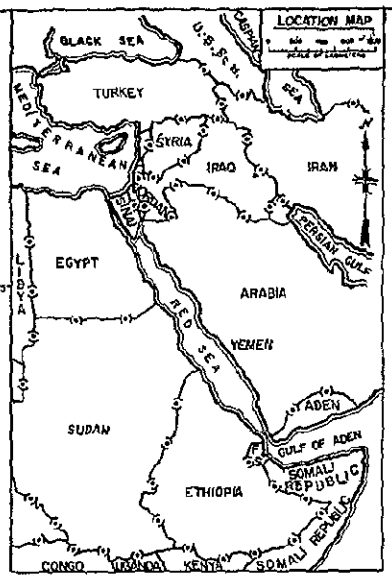
The Alemaya diesel powerplant is about 30 km. south of Dire Dawa. Three sets are installed with a total capacity of 2,910 kv-a. It began operation in 1958 parallel with Ourso. It went into reserve status at the beginning of 1961 when Koka power was made available to this area over the 132-kv. transmission line.



1961 EXISTING INTERCONNECTED SYSTEM
(ADDIS ABABA COMPLEX)

C.L.C.
4.0-Et-13





EXPLANATION

- Perennial river & stream
- Seasonal river & stream
- International boundary
- Principal airport
- Blue Nile Investigation boundary
- Primary all weather roads
- Primary dry-weather roads
- Railroad
- Swamp Area
- Existing hydroelectric powerplants
- Proposed hydroelectric powerplant
- Existing substation
- Proposed substation
- Transmission Line
- Thermal powerplant

30 0 35 70 105 140 175
SCALE OF KILOMETERS

CASE A

MAP OF ETHIOPIA
SHOWING
ELECTRIC POWER FACILITIES
FOR
ADDIS ABABA COMPLEX
UTILIZING
FINCHAA SUB-BASIN POWERPLANTS

Feb 28 1963

4 O-8N-170

Several isolated systems are operated, including Jima, Dessie, Agere Hiywet (Ambo), and Assab, with characteristics as indicated on Table VII-31.

TABLE VII-31 - 1963 ISOLATED SYSTEMS (CASE B)1/

Location	Installed capacity kv.-a.		Firm capacity (kw.)	Production capability (1,000 kw.-hr.)	
	Diesel	Hydro		Diesel	Hydro
Lekkemt	300 2/	--	--	--	--
Jima	1,125	170	600	2,400	300
Dessie	1,125	--	600	2,400	--
Agere Hiywet (Ambo)	--	210	100	--	350
Assab	1,375 3/	--	--	--	--

1/ Based primarily upon January 1962 "Report--Past Activities and Future Programme," EELPA.
2/ 150 kw. in 1962 and 150 kw. in 1963.
3/ 1,000 kw. added in 1963.

Transmission Lines. For the Interconnected System (summarized by Table VII-32), there were 418 km. of 132-kv. lines, 62 km. of 45-kv. lines, and 97 km. of 15-kv. lines--all steel tower except for the 15-kv., some of which is steel pole. Since 1961 some impregnated wood-pole 15-kv. lines have been constructed.

TABLE VII-32 - 1961 INTERCONNECTED SYSTEM--ADDIS ABABA COMPLEX (CASES A AND B)

Location	Voltage (kv.)	Length (km.)	Conductors		Capacity (kw.)
			mm^2	Type	
Koka-Addis Ababa	132	81	3 x 150	ACSR	40,000
Koka-Dire Dawa	131	337	3 x 150	ACSR	10,000
Koka-Nazret 1/	15	12	3 x 53	ACSR	1,000
Koka-Mojo 1/	15	17	3 x 53	ACSR	1,000
Aba Samuel-Akaki	45	17	3 x 22	Cu	5,000
Akaki-Addis Ababa	45	15	3 x 45	Cu	5,000
Akaki-Debre Zeyt 1/	15	23	3 x 53	ACSR	500
Ourso-Dire Dawa	15	30	3 x 12	Cu	250
Alemaya-Dire Dawa	45	30	3 x 22	Cu	2,500
Alemaya-Harar 1/	15	15	3 x 22	Cu	750

1/ Constructed for 45 kv.

232

The 132-kv. lines are operated with the neutral grounded by Petersen 1/ coils, while the 15- and 45-kv. lines have isolated neutrals.

Substations. There are three main high voltage substations in the Interconnected System totaling 39,100 kw. capacity as shown by Table VII-33.

TABLE VII-33 - 1961 INTERCONNECTED SYSTEM--
ADDIS ABABA COMPLEX

Location	Ratio (kv.)	Rating (kv.-a.)	Capacity (kw.)
Addis Ababa	132/15 45/15	2 x 22,000 4 x 1,500	18,000 5,000
Akaki (Acachi)	45/15	1 x 1,500) 1 x 630)	1,700
Dire Dawa	132/15 45/15	2 x 15,000 1 x 3,000	12,000 2,400

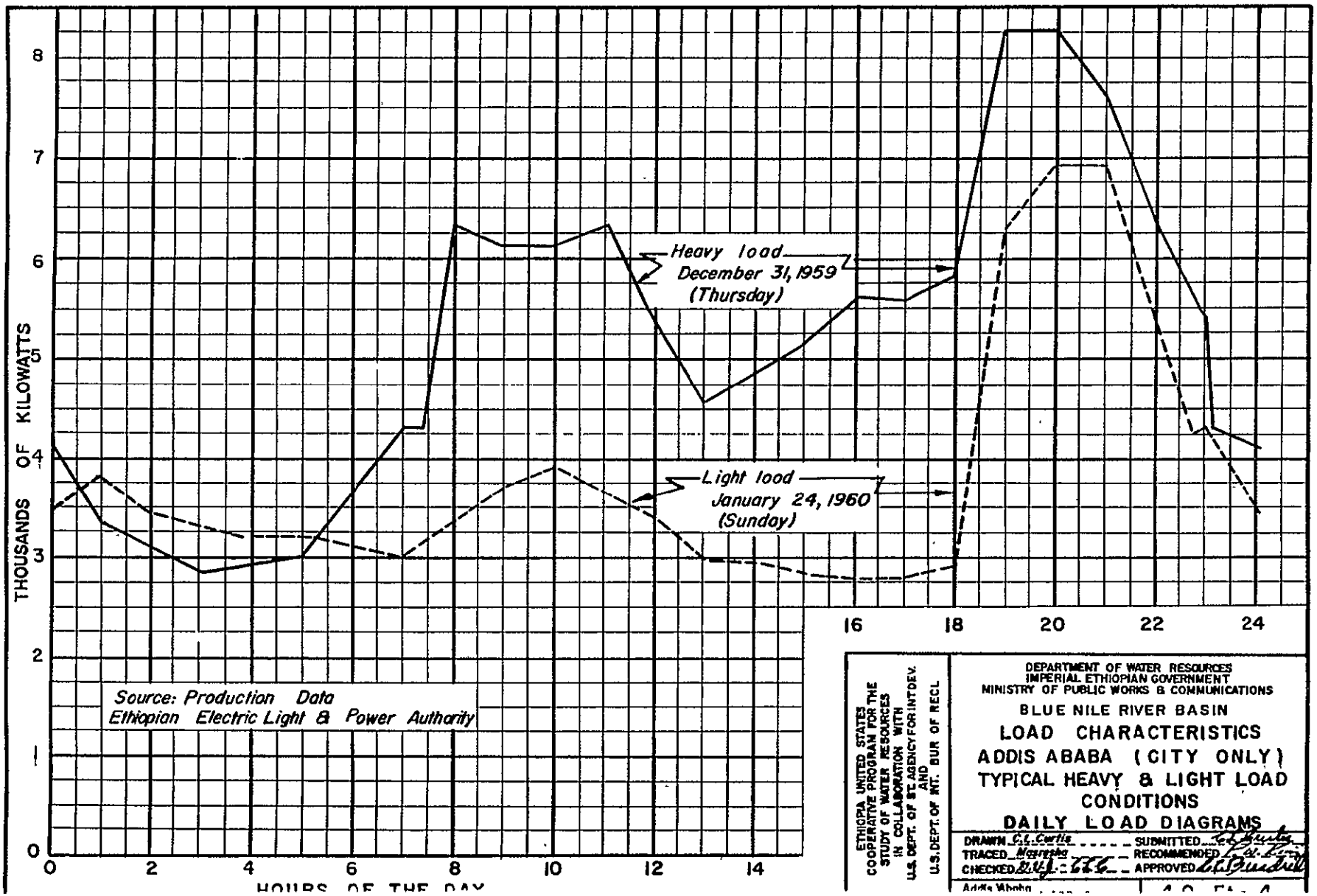
Past, Present, and Future Requirements

Load Centers. For both Cases A and B, the principal load center will be the Addis Ababa Complex. For Case B additional small load centers would be interconnected at specified future dates with the Addis Ababa Complex--those at Lekkemt, Agere Hiywet (Ambo), Jima, Dessie, and Assab. This does not imply that other load centers do not exist; rather, it indicates only that this study is concerned with those load centers likely to be served by the Finchaa Basin hydroelectric powerplants within a 20-year period. The Case A and Case B load centers are as indicated by Drawings Nos. 4.0-BN-169 and 4.0-BN-171, respectively.

Peaks and Monthly Distribution of Energy. The heaviest load in the Addis Ababa Complex (and for that matter, in Ethiopia) is the city of Addis Ababa, and the daily load diagrams for heavy and light load conditions are indicated by Drawing No. 4.0-Et-4. These diagrams do not necessarily imply that the heaviest and lightest loads occurred on the days indicated but are merely examples of a heavy condition and a light condition.

Two peaks seem to occur during the year--August and December--but not consistently so for several reasons. The year's peak seems to occur during the coldest part of the year, which is usually in

1/ Ground-fault neutralizers.



ETHIOPIA UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST. AGENCY FOR INT DEV. AND U.S. DEPT. OF INT. BUR OF RECL

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

LOAD CHARACTERISTICS
ADDIS ABABA (CITY ONLY)
TYPICAL HEAVY & LIGHT LOAD CONDITIONS

DAILY LOAD DIAGRAMS

DRAWN C.L. Curtis SUBMITTED
TRACED Mengesha RECOMMENDED
CHECKED APPROVED

Addis Ababa

December. However, most of the precipitation occurring during the June 15 to September 15 rainy season falls in August, and in a "wet" year the coolness and dampness resulting from cloud cover at those high altitudes can also produce a high demand. Drawing No. 4.0-Et-5 indicates that for one particular period the kw. peaks occurred in the fall (November-December). However, in 1961-62 Drawing No. 4.0-BN-77 shows that the greatest monthly energy requirement occurred in August. This was a particularly "wet" year. For purposes of the Blue Nile studies,1/ the monthly distribution of the annual energy requirements was taken to be as shown by Drawing No. 4.0-BN-78, which shows the maximum requirement falling in December, and August demand as next heavier. This would apply to conditions as they may exist in 1980. It should be understood that there has been an insufficient operating period for the Interconnected System to establish a definite pattern at this time.

For weekly heavy load duration and peak percent curves, see Drawing No. 4.0-BN-118.

Past and Estimated Future Trends of Energy Requirements. A study of the past trend in energy requirements will be meaningless prior to 1960, as the tariff structure and availability of adequate supplies influenced a slower rate of growth than would otherwise have been the situation. In 1960, with the advent of Koka hydroelectric power and the revised tariff structure reflecting lower rates, the annual trend of energy requirements was upward.

A summary of past production of electrical energy by years from 1943 through 1962 is given in Table VII-34. In 1960, 99.99 percent of the total production by EELPA was for the Addis Ababa Complex (Interconnected System), whereas in 1961 the figure was 99.55 percent. Other production was in and for the isolated systems. These figures do not include the north Eritrea systems nor the industrial plants which have generating capacity for their own use.

1/ Operation studies prepared for the Finchaa Sub-Basin facilities assumed a constant monthly requirement equaling about 8.33 percent of the annual. This was done before definite data were obtained, which were not available following at least a year's operation of the Interconnected System starting in mid-1960. Other projects studied later use the distribution as shown by Drawing No. 4.0-BN-78.

TABLE VII-34 - PAST TRENDS OF ENERGY REQUIREMENTS (EXCLUDING ERITREA AND PRODUCTION BY INDUSTRIAL FIRMS)

Interconnected and Isolated Systems					
For year ended Sept. 10	Production (in millions kw.-hr.)			Percent annual increase	Remarks
	Hydro	Thermal	Total		
1943	5.923	1.882	7.805	--	
1944	6.574	1.587	8.161	4.5	Source: EELPA as reported in Ethiopian Economic Review, Nos. 5 and 6.
1945	7.857	1.545	9.402	15.2	
1946	10.057	1.324	11.376	20.0	
1947	11.692	1.330	13.024	14.4	
1948	12.628	1.651	14.279	9.6	
1949	13.658	2.106	15.764	10.3	
1950	14.012	2.868	16.878	7.0	
1951	15.259	3.295	18.554	9.9	
1952	16.608	4.003	20.611	11.0	
1953	19.548	4.486	24.034	16.6	
1954	22.578	4.187	26.745	11.3	
1955	25.980	5.359	31.339	17.1	
1956	25.115	7.954	33.070	5.5	
1957	31.217	5.595	36.812	11.3	
1958	25.740	14.971	40.719	10.6	
1959	27.768	19.333	47.101	15.7	
1960	46.744	8.689	55.433	17.7	Koka on line.
1961	68.106	6.316	74.422	34.3	
1962	--	--	96.500	29.7	

The electrical energy produced for the Addis Ababa Complex (EELPA) as a percent of the total production in the Empire was approximately as follows:

1957	50.2 percent
1958	51.5
1959	53.2
1960	54.4
1961	59.6
1962	63.9

The remainder of the production was by industrial firms for their own use and in north Eritrea, principally by SEDAO in the Massawa-Asmara area.

To forecast the future trend of energy requirements for the Addis Ababa Complex, the best source for the period through 1971 is

	1951 (1958-59)				1952 (1959-60)				1953 (1960-61)				
CATION	Average Load in KW	Peak Load in KW	Load Factor	Power Factor	Average Load in KW	Peak Load in KW	Load Factor	Power Factor	Average Load in KW	Peak Load in KW	Load Factor	Power Factor	Peak demand in KW
ABABA ONLY)	4113	8000	0.514	0.84	5002	9300	0.538	0 87	5200	10200	0.510	0.885	10200 * on Hidar 1953 (Nov 1960)
DAWA & RAR	366	1230	0 298		452	1300	0.348		731	1700	0.430		1700 * on Tahsas 1953 (Dec 1960)
RETH	175	257	0.680	0.80	184	300	0.613	0.86	157	320	0.491		320 * on Hidor 1953 (Nov. 1960)
MA	86	195	0.441		104	305	0.341		105	365	0.288		365 on Meskerm 1953 (Sept. 1960)
SIE	55	135	0.407		59	270	0.218		97	360	0.269		360 on Tahsas 1953 (Dec 1960)
DAR	37	100	0.37		40	140	0.286		52.5	150	0 350		150 on Tahsas 1953 (Dec. 1960)
HIYWET MBO)	27.6	65	0 425		28	92	0 304		32	85	0 376		92 on Guenbot 1952 (May 1960)
BIRHAN	31	75	0 413		35	75	0.467		35	75	0.467		75 KW
GALEM					14	43	0.326		23	64	0.359		64 on Hidor 1953 (Nov. 1960)
MARKOS					12.7	30	0 423		16.4	34	0.482		34 on Tekemte 1953 (Oct. 1960)
JIGA					22 4	36	0 622		23.6	38	0.621		38 on Tahsas 1953 (Dec. 1960)
R DAR									10	32	0.313		32 on Meskerm 1953 (Sept. 1960)

NOTES:

1 Data from Ethiopian Electric Light and Power Authority.

2. Dates are according to Ethiopian calendar with parenthetical entry in equivalent Gregorian calendar.

* Part of Addis Ababa Complex.

ETHIOPIA UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., A I D. AND U.S DEPT OF INT., BUR. OF RECL

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

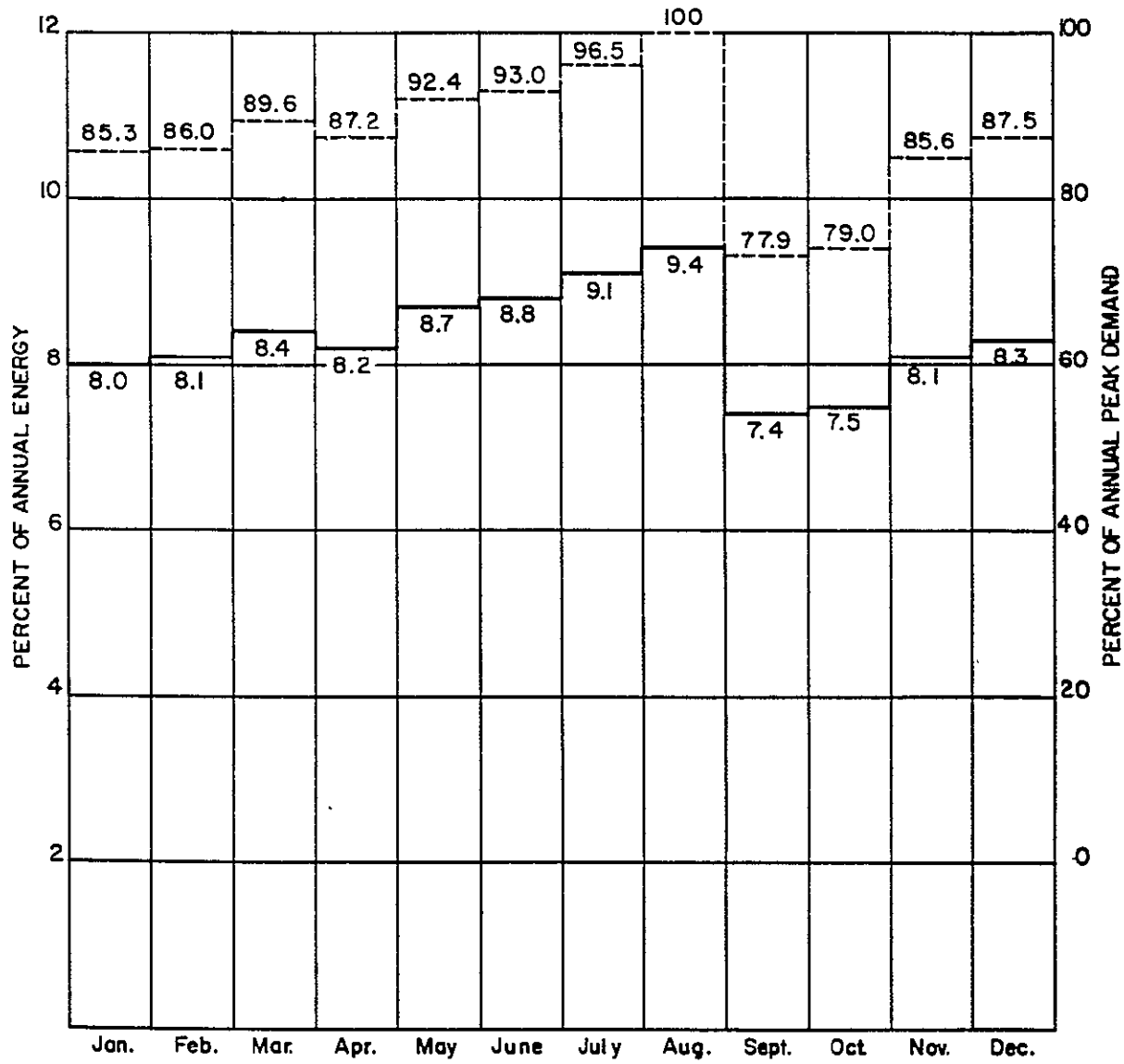
BLUE NILE RIVER BASIN

LOAD CHARACTERISTICS

PRINCIPAL CITIES-ETHIOPIA (EXCLUSIVE OF ERITREA)

DRAWN. C L.C. TRACED A N M. CHECKED SUBMITTED RECOMMENDED APPROVED

Addis Ababa Ethiopia Mar 23, 1963 4.0-Et.-5



——— Percent monthly energy of annual energy

– – – – Percent monthly peak of annual peak demand

Annual load factor 55 percent

For period September 1961 through August 1962,

Koka Interconnected System.

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., A.I.D. AND U.S. DEPT. OF INT., BUR. OF RECL.

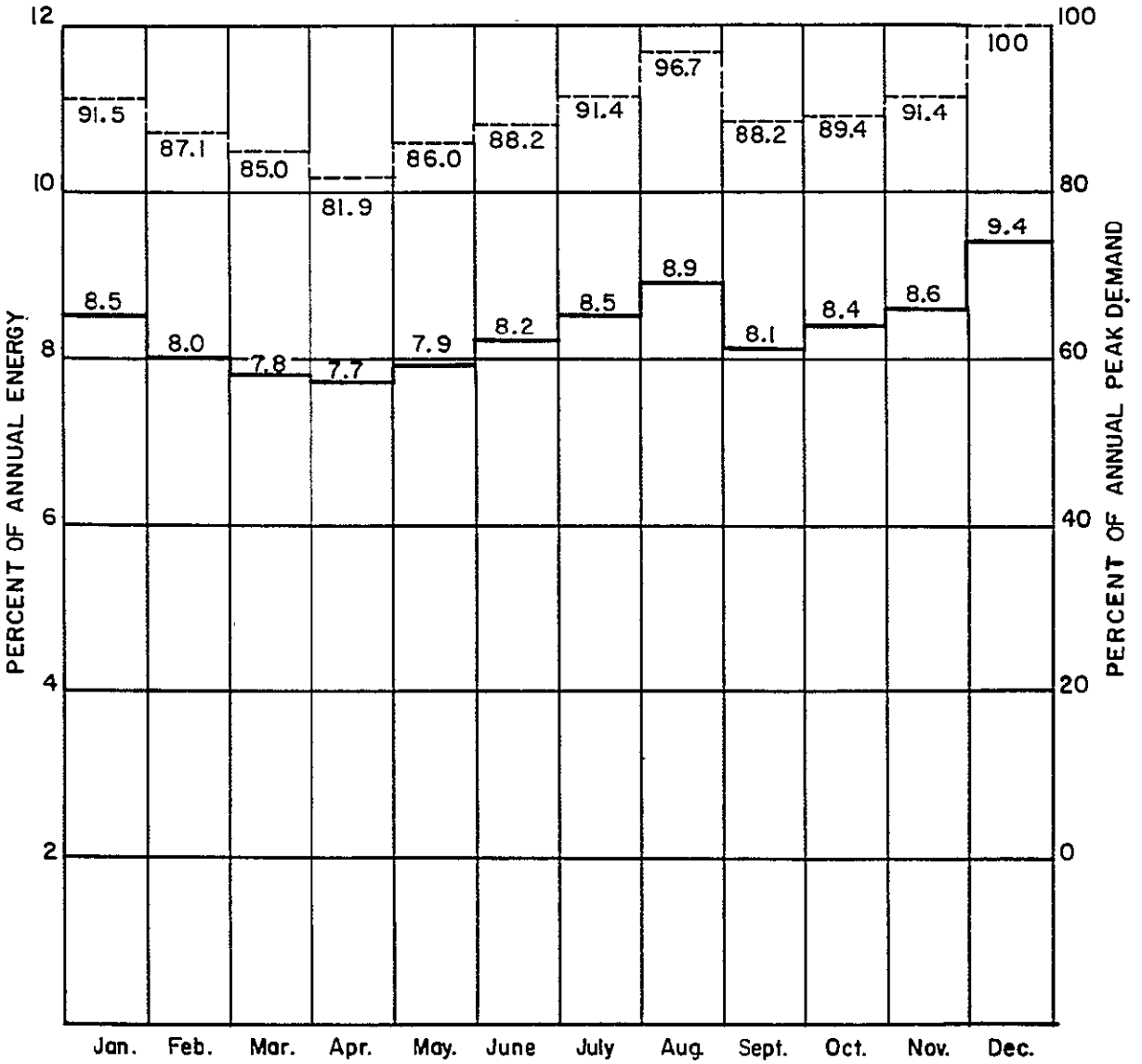
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

1961–62 LOAD CHARACTERISTICS MONTHLY DISTRIBUTION INTERCONNECTED SYSTEM

DRAWN C.L.C. SUBMITTED C.L.C.
TRACED A.N.M. RECOMMENDED P.W.K.
CHECKED C.L.C. APPROVED C.E.B.

Addis Ababa Ethiopia Dec. 14, 1962 | 4.0-BN-77



——— Percent monthly energy of annual energy.

– – – – Percent monthly peak of annual peak demand.

Annual load factor 60 percent.

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., A.I.D. AND U.S. DEPT. OF INT., BUR. OF RECL.

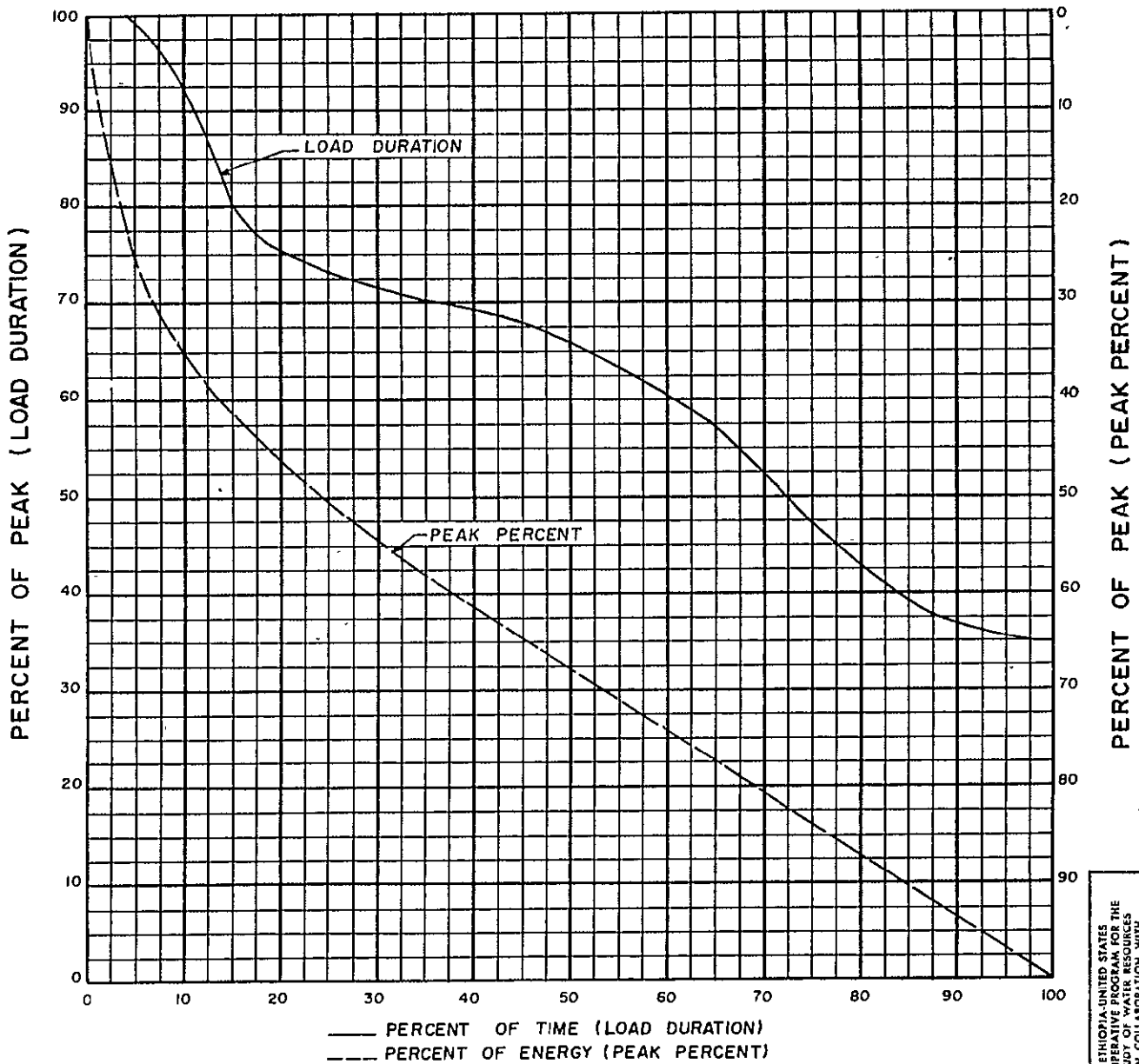
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

FUTURE LOAD CHARACTERISTICS
MONTHLY DISTRIBUTION
INTERCONNECTED SYSTEM

DRAWN C.L.C. SUBMITTED C.L.C.
TRACED A.N.M. RECOMMENDED P.W.K.
CHECKED C.L.C. APPROVED C.E.B.

Addis Ababa Ethiopia Dec. 24, 1962 | 4.0—BN—78



PEAK LOAD WEEK IN DECEMBER

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST. AGENCY FOR INT. DEV. AND U.S. DEPT OF INT BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN
FUTURE LOAD CHARACTERISTICS
LOAD DURATION & PEAK PERCENT CURVES
HEAVY LOAD CONDITIONS
INTERCONNECTED SYSTEM
(EXCLUDING ERITREA)

DRAWN G.L.C. SUBMITTED G.L.C.
TRACED ASSEFA A RECOMMENDED P.W.K.
CHECKED G.L.C. APPROVED C.E.B.

Addis Ababa Ethiopia MARCH 22, 1963 | 4.0—BN—118

the EELPA, which has indicated that the annual growth rate will be 22 percent through 1966 and will taper off to 17 percent by 1971. This is for the general, industrial, and commercial requirements but does not consider certain possible off-peak sales. Annual increases resulting from total production meeting off-peak as well as general requirements would be modified as follows:

1963	29.4 percent
1964	0
1965	13.6
1966	44.0
1967	16.7
1968	19.0
1969	20.0
1970	16.7
1971	14.3

By 1980, the growth rate may still be around 10 percent, but will taper off significantly after that year. These higher rates in the earlier years have to be maintained if the objectives of the successive five-year plans are to be approached or reached.

Losses. Actual losses for the Interconnected System (Addis Ababa Complex) from 1957 through 1961 have been reported as follows[1] and as further indicated in Table VII-35.

Year	Millions of kw.-hr.			Percent Losses
	Production	Sales	Losses	
1957	35.5	25.3	10.2	29
1958	39.1	27.5	11.6	30
1959	45.0	33.5	11.5	34
1960	51.6	41.0	10.6	21
1961	60.3	50.2	10.1	17*

* Year of interconnection to Koka.
Includes some transmission losses.

1/ Source, EELPA, January 1962 Report.

24

TABLE VII-35 - ENERGY AND DEMAND AT LOAD CENTER--ADDIS ABABA COMPLEX (CASES A AND B)

Year	Millions of kw.-hr. at high-voltage side of receiving-end substation			Per-cent annual load factor	Peak demand (kw.) at load	Peak demand kw. (rounded) at load
	Customer loads	Losses	Total			
1957	25.3	10.2	35.5	50	8,105	8,100
1958	27.5	11.6	39.1	51	8,752	8,800
1959	33.5	11.5	45.0	51.4	10,000	10,000
1960	41.0	10.6	51.6	53.8	10,949	11,000
1961	50.2	8.5	58.7	51.0	13,139	13,100
1962	75.0	7.9	82.9	53.8	17,591	17,600
1963	95.0	12.2	107.2	54.6	22,413	22,400
1964	95.0	12.2	107.2	54.6	22,413	22,400
1965	110.0	11.8	121.8	54.9	25,326	25,300
1966	155.0	20.5	175.5	58.7	34,130	34,100
1967	185.0	20.0	205.0	57.1	40,984	41,000
1968	220.0	23.7	243.7	57.1	48,721	49,000
1969	260.0	32.3	292.3	57.1	58,437	58,400
1970	305.0	36.3	341.3	57.1	68,233	68,200
1971	350.0	40.0	390.0	57.1	77,969	78,000
1972	399.0	45.6	444.6	57	89,041	89,000
1973	450.0	54.4	504.4	57	101,017	101,000
1974	513.0	58.4	571.4	58	112,462	112,500
1975	578.0	65.6	643.6	58	126,673	126,700
1976	648.0	73.6	721.6	58	142,025	142,000
1977	726.0	83.2	809.2	58	159,266	159,300
1978	807.0	92.0	899.0	58	176,940	177,000
1979	894.0	101.6	995.6	59	192,632	192,700
1980	985.0	112.0	1,097.0	59	212,251	212,300

Estimated losses for the same system through 1971 were as follows. 1/

1962	12 percent
1963	14
1964	14
1965	12
1966	14
1967	12
1968	12
1969	13
1970	13
1971	13

It should be understood that loss figures include meter errors and some system usage.

Losses for the isolated systems, which will be interconnected with the Addis Ababa Complex in the late 1970's as assumed for Case B in this study, will be somewhat higher; but, since the percent of the total production serving these added loads will be very small in comparison with the Addis Ababa Complex itself, the effect upon total system losses will be small. Tables VII-36, VII-37, VII-38, VII-39, and VII-40 show those losses.

Energy and Demand at Load Centers

Addis Ababa Complex. The energy and demand for the Addis Ababa Complex (Interconnected System) as seen from the 161-kv. side of a proposed substation near Addis Ababa are shown by Table VII-35, which indicates loads, losses, annual load factors, and peak demand. This is true for both Cases A and B.

Table VII-41 shows the breakdown of sales by the two major classes used. This applies to Case A only. Table VII-42 indicates the peak demand at load and at the powerplant for Case A only.

1/ Source, EELPA, January 1962 Report. (Includes transmission losses, whereas Table VII-35 does not.)

24

Agere Hiywet (Ambo), Case B only. Table VII-36 indicates the conditions at load, historical through 1960 and projected after that date. Total customer loads distributed by classes are shown on Table VII-43.

For this particular study, the connection of this isolated load to the Interconnected System was assumed to occur at the end of 1973.

Lekkemt (Case B only). Table VII-37 shows anticipated conditions beginning in 1963 through 1980 with Lekkemt being served by its own isolated diesel-electric system until connection with the Interconnected System is made in 1974. Total customer loads distributed by classes were estimated as shown on Table VII-44.

Jima (Case B only). Historial data through 1961 are shown on Table VII-38 with load forecasts from 1961 through 1980. As indicated in a prior section, Jima is served by its own isolated system, consisting of both hydro and diesel. Connection to the Interconnected System was assumed to occur in 1974. As is the situation with some of the other isolated systems, other facilities, such as larger hydroelectric systems, can be installed to serve an isolated system initially but can be connected later with the main Interconnected System when it expands. This possibility exists at Jima, where a larger plant on the Great Gibe River could be installed to carry the Jima load until interconnection was accomplished. Whether this is done or not is immaterial insofar as this particular study is concerned, except that when interconnection is made, all load is assumed to be carried by the Interconnected System with diesel sets moved elsewhere and the hydroelectric installations maintained for reserve or emergency use.

Total customer loads distributed by classes were as shown on Table VII-45.

Dessie (Case B only). Historical data from 1957 through 1960 are indicated with the projections going to 1980. Table VII-39 shows customer loads, losses, load factor, and peak demand by years for this load center with the tie to the Interconnected System occurring in 1977. Sales by classes of energy are as indicated in Table VII-46.

South Eritrea (Assab), Case B only. The EELPA acquired the existing electric supply and distribution facilities from a private operator in 1962, and EELPA forecasts the production and

TABLE VII-36 - ENERGY AND DEMAND AT LOAD CENTER--
AGERE HIYWET (AMBO), CASE B

Year	Thousands of kw.-hr. at high-voltage side of receiving-end substation			Per-cent annual load factor	Peak demand (kw.) at load	Remarks
	Customer loads	Load center losses	Load center total			
1957	137	64	201	30	76	Isolated System
1958	161	87	248	35	81	
1959	212	95	307	43	82	
1960	242	65	307	35	100	
1961	312	55	367	37	113	
1962	367	70	437	38	131	
1963	432	88	520	39	152	
1964	509	104	613	41	171	
1965	605	123	723	43	192	
1966	702	143	845	44	219	
1967	820	168	988	45	251	
1968	959	197	1,156	45	293	
1969	1,123	230	1,353	45	343	
1970	1,314	269	1,583	45	402	
1971	1,497	307	1,804	45	458	
1972	1,707	350	2,057	45	522	
1973	1,941	398	2,339	46	580	Inter-connect
1974	2,198	383	2,581	46	641	Inter-connected System
1975	2,477	432	2,909	47	707	
1976	2,779	485	3,264	47	793	
1977	3,251	568	3,819	47	928	
1978	3,641	636	4,277	47	1,039	
1979	4,030	704	4,734	48	1,126	
1980	4,441	776	5,217	48	1,241	

24

TABLE VII-37 - ENERGY AND DEMAND AT LOAD CENTER--
LEKKEMT (CASE B)

Year	Thousands of kw.-hr. at high-voltage side of receiving-end substation: Customer loads	Load center losses	Load center total	Per-cent annual load factor	Peak demand (kw.) at load	Remarks
1962	280	70	350	25	160	
1963	454	106	560	30	213	
1964	781	171	952	35	311	
1965	1,264	259	1,522	36	483	
1966	1,897	388	2,285	37	705	
1967	2,655	544	3,199	38	961	
1968	3,586	734	4,320	39	1,264	Isolated System
1969	4,661	955	5,616	40	1,603	
1970	6,059	1,241	7,300	40	2,083	
1971	7,574	1,551	9,125	41	2,541	
1972	9,088	1,862	10,950	41	3,049	
1973	10,907	2,233	13,140	42	3,571	Inter-
1974	12,979	2,267	15,246	43	4,047	connect
1975	14,879	2,599	17,378	43	4,613	
1976	17,408	3,041	20,449	43	5,429	
1977	20,192	3,528	23,720	43	6,197	
1978	23,473	4,091	27,514	43	7,304	Inter-connected System
1979	26,936	4,705	31,641	43	8,400	
1980	30,707	5,364	36,071	44	9,358	

TABLE VII-38 - ENERGY AND DEMAND AT LOAD CENTER--
JIMA (CASE B)

Year	Thousands of kw.-hr. at high-voltage side of receiving-end substation			Per-cent annual load factor	Peak demand (kw.) at load	Remarks
	Customer loads	Load center losses	Load center total			
1957	325	153	478	25	218	Isolated System
1958	358	192	550	25	251	
1959	412	185	597	44	155	
1960	643	271	914	34	306	
1961	1,167	206	1,373	29	540	
1962	1,517	267	1,784	32	636	
1963	1,896	334	2,230	34	749	
1964	2,351	414	2,765	36	877	
1965	2,891	510	3,401	38	1,022	
1966	3,527	622	4,149	40	1,184	
1967	4,267	753	5,020	42	1,364	
1968	5,121	903	6,024	45	1,528	
1969	6,093	1,075	7,168	45	1,818	
1970	7,190	1,268	8,458	45	2,145	
1971	8,412	1,484	9,896	45	2,510	
1972	9,943	1,707	11,650	45	2,955	
1973	10,930	1,929	12,859	46	3,191	Inter-connect
1974	12,132	1,784	13,916	46	3,453	Inter-connected System
1975	13,224	1,945	15,169	46	3,764	
1976	14,293	2,092	16,385	46	4,066	
1977	15,425	2,268	17,693	46	4,391	
1978	16,505	2,427	18,932	47	4,598	
1979	17,660	2,597	20,257	47	4,920	
1980	18,896	2,778	21,674	47	5,264	

TABLE VII-39 - ENERGY AND DEMAND AT LOAD CENTER--
DESSIE (CASE B)

Year	Thousands of kw.-hr. at high-voltage side of receiving-end substation			Per-cent annual load factor	Peak demand (kw.) at load	Remarks
	Customer loads	Load center losses	Load center total			
1957	161	76	237	25	108	Isolated System
1958	166	89	255	25	116	
1959	206	93	299	41	83	
1960	370	98	468	22	243	
1961	762	134	896	26	393	
1962	1,487	305	1,792	30	682	
1963	2,603	533	3,136	33	1,085	
1964	4,165	853	5,018	35	1,637	
1965	5,831	1,194	7,025	37	2,167	
1966	7,580	1,553	9,133	40	2,606	
1967	9,400	1,925	11,325	43	3,007	
1968	11,656	2,387	14,043	44	3,643	
1969	13,986	2,865	16,851	45	4,275	
1970	16,783	3,438	20,221	46	5,018	
1971	20,140	4,125	24,265	46	6,022	
1972	23,967	4,908	28,875	46	7,166	
1973	28,520	5,841	34,361	46	8,527	
1974	33,652	6,893	40,545	46	10,062	
1975	39,710	8,133	47,843	46	11,873	
1976	46,460	9,516	55,976	46	13,891	Inter-connect
1977	54,359	9,496	63,855	47	15,509	Inter-connected System
1978	63,056	11,016	74,072	47	17,991	
1979	73,145	12,779	85,924	47	20,870	
1980	84,117	14,695	98,812	47	24,000	

249

TABLE VII-40 - ENERGY AND DEMAND AT LOAD CENTER--
SOUTH ERITREA (CASE B)

Year	Thousands of kw.-hr. at high-voltage side of receiving-end substation: Customer loads	Load center losses	Load center total	Per-cent annual load factor	Peak demand (kw.) at load	Remarks
1959	1,200	500	1,700	33	588	Isolated System
1960	1,380	460	1,840	40	525	
1961	1,500	480	1,980	45	502	
1962	1,700	430	2,130	52	468	
1963	2,410	570	2,980	59	577	
1964	3,130	740	3,870	60	736	
1965	4,050	950	5,000	55	1,038	
1966	5,260	1,240	6,500	50	1,484	
1967	6,850	1,600	8,450	48	2,009	
1968	15,250	3,350	18,600	65	3,267	
1969	22,900	4,200	27,100	65	4,759	
1970	22,940	5,040	27,980	64	4,991	
1971	30,340	6,660	37,000	65	6,498	
1972	38,540	8,460	47,000	65	8,254	
1973	46,030	9,430	55,460	64	9,892	
1974	53,400	10,930	64,330	62	11,845	
1975	61,930	12,690	74,620	60	14,197	
1976	72,080	13,730	85,810	59	16,603	Inter-connect
1977	82,890	13,330	96,220	58	18,938	Inter-connected System
1978	96,600	15,530	112,130	60	21,333	
1979	102,480	16,470	118,950	62	21,901	
1980	114,780	18,450	133,230	62	24,530	

25

TABLE VII-41 - SALES BY CLASSES--ADDIS ABABA COMPLEX (CASE A)

Year	In millions of kw.-hr.		
	National economy	Public consumption	Total
1957	10.3	15.0	25.3
1958	11.5	16.0	27.5
1959	14.4	19.1	33.5
1960	18.0	23.0	41.0
1961	22.6	27.6	50.2
1962	34.0	41.0	75.0
1963	43.5	51.5	95.0
1964	43.9	51.1	95.0
1965	51.3	58.7	110.0
1966	72.8	82.2	155.0
1967	87.7	97.3	185.0
1968	105.1	114.9	220.0
1969	125.3	134.7	260.0
1970	148.2	156.8	305.0
1971	171.5	178.5	350.0
1972	197.1	201.9	399.0
1973	224.1	225.9	450.0
1974	257.5	255.5	513.0
1975	292.5	285.5	578.0
1976	330.0	318.0	648.0
1977	373.0	353.0	726.0
1978	418.0	389.0	807.0
1979	467.0	427.0	894.0
1980	518.0	467.0	985.0

25

TABLE VII-42 - ESTIMATED PEAK DEMAND--INTERCONNECTED SYSTEM, ADDIS ABABA COMPLEX (CASE A)

Year	Peak demand at load (kw.)	Transmission losses at peak demand (kw)	Peak demand at powerplant (kw.)	Peak demand at powerplant kw. (rounded)
1961	13,139	731	13,870	13,900
1962	17,591	959	18,550	18,600
1963	22,413	1,279	23,692	23,700
1964	22,413	1,279	23,692	23,700
1965	25,326	1,462	26,788	26,800
1966	34,130	2,055	36,185	36,200
1967	40,984	2,283	43,267	43,300
1968	48,721	2,877	51,598	51,600
1969	58,437	3,516	61,953	62,000
1970	68,233	3,973	72,206	72,200
1971	77,969	4,566	82,535	82,600
1972	89,041	5,205	94,246	94,300
1973	101,017	6,210	107,227	107,300
1974	112,462	6,667	119,129	119,100
1975	126,673	7,466	134,139	134,100
1976	142,025	8,400	150,425	150,400
1977	159,266	9,500	168,766	169,000
1978	176,940	10,500	187,440	187,500
1979	192,632	11,600	204,232	204,000
1980	212,251	12,785	225,036	225,000
1981	232,799	14,155	246,954	247,000

TABLE VII-43 - SALES BY CLASSES--AGERE HIYWET (AMBO), CASE B

Year	In thousands of kw.-hr.		
	National economy	Total consumption	Total
1957	34	103	137
1958	40	121	161
1959	53	159	212
1960	62	180	242
1961	82	230	312
1962	98	269	367
1963	118	314	432
1964	143	366	509
1965	172	428	600
1966	205	497	702
1967	244	576	820
1968	292	667	959
1969	348	775	1,123
1970	415	899	1,314
1971	482	1,015	1,497
1972	559	1,148	1,707
1973	648	1,293	1,941
1974	747	1,451	2,198
1975	857	1,620	2,477
1976	978	1,801	2,779
1977	1,163	2,088	3,251
1978	1,325	2,316	3,641
1979	1,491	2,539	4,030
1980	1,670	2,771	4,441

TABLE VII-44 - SALES BY CLASSES--LEKKEMT
(CASE B)

Year	In thousands of kw.-hr.		
	National economy	Public consumption	Total
1963	114	340	454
1964	198	583	781
1965	326	938	1,264
1966	497	1,400	1,897
1967	706	1,949	2,655
1968	968	2,618	3,586
1969	1,277	3,384	4,661
1970	1,684	4,373	6,059
1971	2,136	5,438	7,574
1972	2,599	6,489	9,088
1973	3,163	7,744	10,907
1974	3,816	9,163	12,979
1975	4,434	10,445	14,879
1976	5,257	12,151	17,408
1977	6,063	13,752	19,815
1978	7,261	16,162	23,423
1979	8,458	18,478	26,936
1980	9,765	20,819	30,707

254

TABLE VII-45 - SALES BY CLASSES--JIMA (CASE B)

Year	In thousands of kw.-hr.		
	National economy	Public consumption	Total
1957	81	244	325
1958	89	269	358
1959	103	309	412
1960	161	482	643
1961	296	1,463	1,167
1962	391	1,126	1,517
1963	497	1,399	1,896
1964	625	1,726	2,351
1965	780	2,111	2,891
1966	966	2,561	3,527
1967	1,186	3,081	4,267
1968	1,444	3,677	5,121
1969	1,742	4,351	6,093
1970	2,085	5,105	7,190
1971	2,473	5,939	8,412
1972	2,963	6,980	9,943
1973	3,300	7,630	10,930
1974	3,712	8,420	12,132
1975	4,099	9,125	13,224
1976	4,488	9,805	14,293
1977	4,095	10,520	15,425
1978	5,315	11,190	16,505
1979	5,757	11,903	17,660
1980	6,235	12,661	18,896

TABLE VII-46 - SALES BY CLASSES--DESSIE (CASE B)

Year	In thousands of kw.-hr.		
	National economy	Public consumption	Total
1957	40	121	161
1958	41	125	166
1959	52	154	206
1960	92	278	370
1961	194	568	762
1962	384	1,103	1,487
1963	682	1,921	2,603
1964	1,108	3,057	4,165
1965	1,574	4,257	5,831
1966	2,077	5,503	7,580
1967	2,613	6,787	9,400
1968	3,287	8,369	11,656
1969	4,000	9,986	13,986
1970	4,867	11,916	16,783
1971	5,921	14,219	20,140
1972	7,142	16,825	23,967
1973	8,613	19,907	28,520
1974	10,298	23,354	33,652
1975	12,310	27,400	39,710
1976	14,588	31,872	46,460
1977	17,286	37,073	54,359
1978	20,304	42,752	63,056
1979	23,845	49,300	73,145
1980	27,759	56,358	84,117

sales as follows through 1971, using an increase of 30 percent for five years and 20 percent for the last five.

Year	Thousands of kw.-hr.		
	Sales	Losses	Production
1962	5,000	1,000	6,000
1963	7,500	1,500	9,000
1964	9,500	1,500	11,000
1965	12,000	2,000	14,000
1966	16,000	4,000	20,000
1967	21,000	4,000	25,000
1968	26,000	5,000	31,000
1969	32,000	5,000	37,000
1970	39,000	5,000	44,000
1971	47,000	6,000	53,000

Studies using Table VII-40 were prepared prior to the availability of this information; and, although in general it uses about the same rate of initial growth, the base loads for 1959-1961 are considerably lower. However, both estimates would approach about the same values at the assumed date of connection in 1977 to the Interconnected System, so there is no appreciable effect upon the objective of this particular study.

Sales by classes of energy are as shown on Table VII-47.

Summary

Tables VII-35, VII-41, and VII-48 summarize the estimated future requirements by showing the peak demand at load centers, diversity factor, peak demand of the interconnected load, transmission losses at peak demand, and the peak demand at the Finchaa Sub-Basin powerplants. (Tables VII-35 and VII-41 indicate conditions for Case A, and Table VII-48 for Case B.)

Estimated Future Need for Additional Generator Capacity--1964-1967

Table VII-30 gives the firm kilowatt capacity of the existing Interconnected System (Addis Ababa Complex) as 30,000 kw., including the Alemaya diesel but not the Addis Ababa steam plant. Keeping Alemaya (2,000 kw.) in reserve (because of its higher operating cost) leaves 28,000 kw. of firm capacity.

TABLE VII-47 - SALES BY CLASSES--SOUTH ERITREA (CASE B)

Year	In thousands of kw.-hr.		
	National economy	Public consumption	Total
1962	1,190	510	1,700
1963	1,570	840	2,410
1964	1,880	1,250	3,130
1965	2,030	2,020	4,050
1966	2,100	3,160	5,260
1967	2,400	4,450	6,850
1968	10,680	4,570	15,250
1969	16,030	6,870	22,900
1970	15,600	7,360	22,940
1971	21,240	9,100	30,340
1972	26,980	11,560	38,540
1973	31,300	14,730	46,030
1974	35,240	18,160	53,400
1975	37,160	24,770	61,930
1976	41,810	30,270	72,080
1977	45,590	37,300	82,890
1978	57,960	38,640	96,600
1979	63,170	39,310	102,480
1980	72,310	42,470	114,780

TABLE VII-48 - ESTIMATED PEAK DEMAND--INTERCONNECTED SYSTEM (CASE B)

	Kilowatts											
	Peak Demand at Load Centers											
Year	Addis Ababa	Agere Hiywet (Ambo)	Lekkemt	Jima	Dessie	South Eritrea (Assab)	Sum	Diversity factor	Peak demand of interconnected load	Transmission losses at peak demand	Peak demand at power-plant	Peak demand at power-plant (rounded)
1957	8,105						8,105		8,105			
1958	8,752						8,752		8,752			
1959	10,000						10,000		10,000			
1960	10,949						10,949		10,949			
1961	13,139						13,139		13,139	731	13,870	13,900
1962	17,591						17,591		17,591	959	18,550	18,600
1963	22,413						22,413		22,413	1,279	23,692	23,700
1964	22,413						22,413		22,413	1,279	23,692	23,700
1965	25,326						25,326		25,326	1,462	26,788	26,800
1966	34,130						34,130		34,130	2,055	36,185	36,200
1967	40,984						40,984		40,984	2,283	43,267	43,300
1968	48,721						48,721		48,721	2,877	51,598	51,600
1969	58,437						58,437		58,437	3,516	61,953	62,000
1970	68,233						68,233		68,233	3,973	72,206	72,200
1971	77,969						77,969		77,969	4,566	82,535	82,600
1972	89,041						89,041		89,041	5,205	94,246	94,300
1973	101,017						101,017		101,017	6,210	107,227	107,300
1974	112,462	641	4,047	3,453			120,603	1.05	114,860	6,704	121,564	121,600
1975	126,673	707	4,613	3,764			135,757	1.06	128,073	7,529	135,601	135,600
1976	142,025	793	5,429	4,066			152,313	1.06	143,692	8,447	152,139	152,100
1977	159,266	928	6,197	4,391	15,509	18,938	205,229	1.15	179,460	10,346	188,806	188,800
1978	176,940	1,039	7,304	4,598	17,991	21,333	229,205	1.15	199,309	11,542	210,851	210,900
1979	192,632	1,126	8,400	4,920	20,870	21,901	249,849	1.15	217,260	12,747	230,007	230,000
1980	212,251	1,241	9,358	5,264	24,000	24,530	276,644	1.15	240,560	13,995	254,555	255,000

There are several industrial plants generating for their own use, and the annual generated energy is indicated on Drawing No. 4.0-BN-148. These plants are not operated so as to contribute any support to the Interconnected System, and percentagewise they will ultimately represent only a small part of the total energy generated.

Table VII-49 gives an indication of the adequacy of the present power supply through 1967.

TABLE VII-49 - DEPENDABLE SYSTEM CAPACITY TO MEET PEAK DEMAND VERSUS SYSTEM COINCIDENTAL PEAK DEMAND AT PLANT--1964-1967 (CASE A OR B)

	Kilowatts		
Year	Dependable system capacity	System coincidental peak demand	Surplus (+) or deficit (-)
1964	28,000	23,700	+4,300
1965	28,000	26,800	+1,200
1966	28,000	36,200	-8,200
1967	28,000	43,300	-15,300

By the end of 1965, only a small surplus capacity will exist (1,200 kw.) using the three dependable low cost hydro sources. However, if the Addis Ababa steam plant and the Alemaya diesel were used, an additional 7,000 kw. of dependable capacity would become available, changing the 1965 surplus of 1,200 kw. to a surplus of 8,200 kw. and the 1966 deficit of 8,200 kw. to a deficit of 1,200 kw. Therefore, even with all available resources in operation, new generation will be required by the end of 1965.

Power Facilities Planned or Under Consideration--1964-1967

The EELPA is planning the construction of two medium-head hydroelectric developments of 37 mw. each, known as Awash No. 2 and Awash No. 3. (The first development on the Awash River was Koka.) These two will be located on the Awash River about 120 km. southeast of Addis Ababa. The main water regulation will be supplied by the Koka reservoir, but smaller dams will be necessary at each plant for sufficient forebay storage to provide minimum regulation to meet

the hourly load curve. In addition to the dam and the required intake structure for the power facilities, each installation will have a five-meter pressure tunnel, surge tank, valve chamber, two penstocks of three-meter diameter, a powerhouse for two Francis turbines with necessary service facilities, and an open-air switch yard. The effective head of each development is to be approximately 60 meters, and the distance between the intake and the powerhouse will be 2,000 meters for Awash No. 2 and 900 meters for Awash No. 3. Designs have been completed, and it appears that construction of Awash No. 2 will start in early 1964, with two years to complete. Construction of Awash No. 3 will follow immediately. On this basis, Awash No. 2 may be energized at the end of 1965 and Awash No. 3 by the end of 1967.

Estimated Future Deficiency in Power Supply--1968-1980

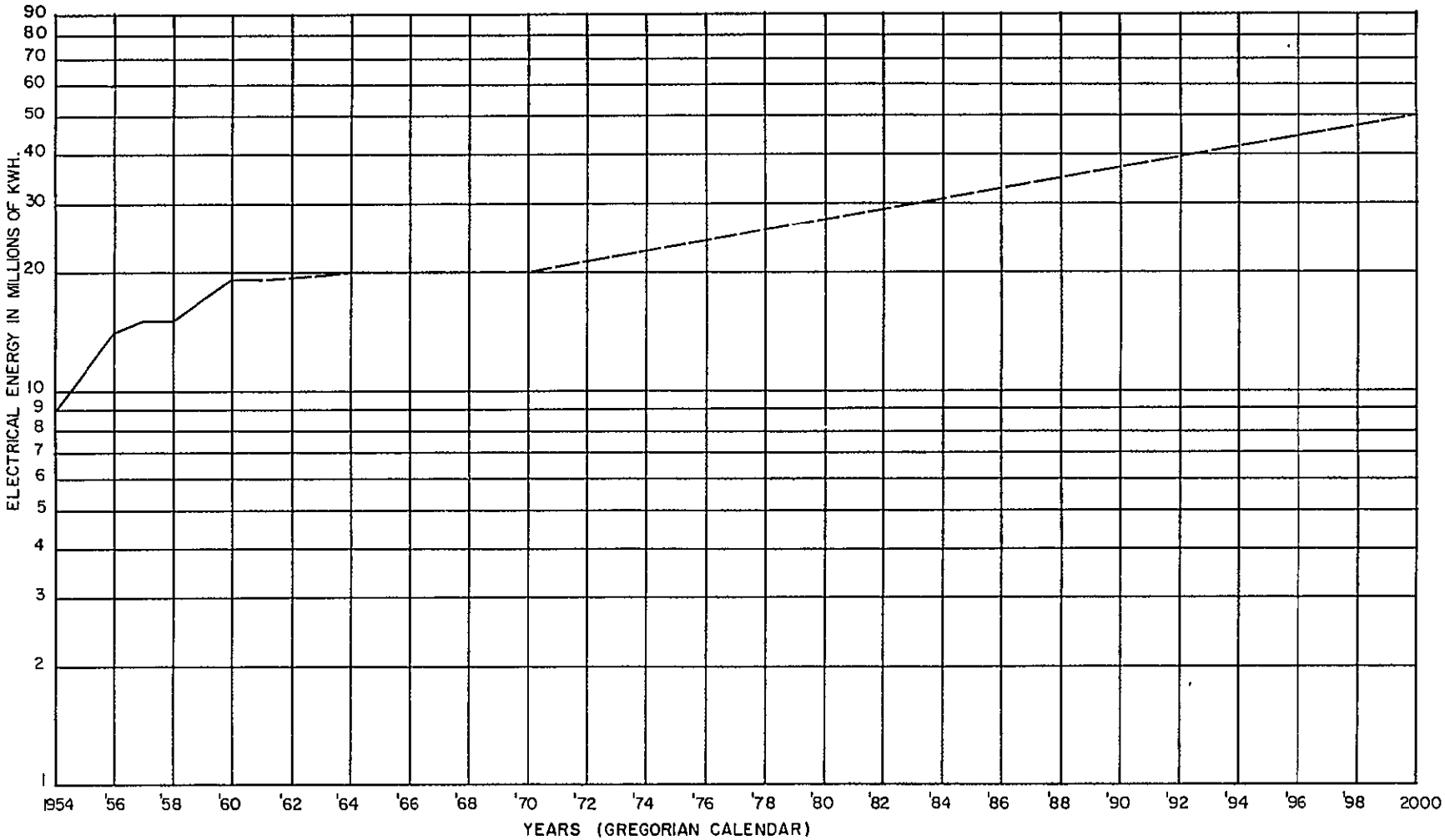
If the objectives of the second and subsequent five-year development plans for the Empire are to be approached or reached, wherein the present agricultural economy is to be successfully transformed into an agricultural-industrial one by 1982, the need for energy to meet industrial as well as residential and commercial requirements will be substantial.

Table VII-49 indicates that the first deficiency in system capability would occur in 1966, meaning that additional generating capacity would be required by the end of 1965. By that time, Awash No. 2 would be placed in operation, followed by Awash No. 3 at the end of 1967. Considering the capability of these installations, Tables VII-50 and VII-51 summarize the anticipated system conditions anticipated through 1980 for Cases A and B, respectively.

Under both Cases A and B, new generating facilities should go on the line in 1974 so as to insure adequate capability for load and reserves. This presupposes that the fourth and last Awash plant would have been placed in operation in 1971.

Finchaa Sub-Basin as a Source in Meeting Future Deficiencies in Power Supply

As described in a previous section, the Finchaa Sub-Basin has two, high-head, hydroelectric powerplant possibilities--one on the Finchaa River and the other on the Neshe River. Each has the capability of meeting a peak demand of about 80 mw. during an adverse water year. They are located within 30 kilometers airline distance of each other. The most economical power will come from the Finchaa powerplant, and it probably would be developed first.



——— Historical

— — — Forecast

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., A.I.D. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

PRODUCTION OF ELECTRICITY BY INDUSTRIAL FIRMS

DRAWN C.L. CURTIS
TRACED A.N. MUSSA
CHECKED C.L.C - G.V.J
SUBMITTED C.L.C
RECOMMENDED P.W.K.
APPROVED C.E.B.

Addis Ababa Ethiopia Apr 30, 1963 | 40-BN-148

TABLE VII-50 - DEPENDABLE SYSTEM CAPACITY TO MEET PEAK DEMAND VERSUS SYSTEM COINCIDENTAL PEAK DEMAND AT PLANT--1968-1980 (CASE A)

Year	Dependable system capacity (kw.)	System coincidental peak demand (kw.)	Surplus (+) or deficit (-) (kw.)	Remarks
1966	65,000	36,200	+28,800	37-mw. Awash No. 2 added
1967	65,000	43,300	+21,700	
1968	102,000	51,600	+50,400	37-mw. Awash No. 3 added
1969	102,000	62,000	+40,000	
1970	102,000	72,200	+29,800	
1971	139,000	82,600	+56,400	37-mw. Awash No. 4 added
1972	139,000	94,300	+44,700	
1973	139,000	107,300	+31,700	
1974	139,000	119,100	+19,900	
1975	139,000	134,100	+4,900	
1976	139,000	150,400	-11,400	
1977	139,000	169,000	-30,000	
1978	139,000	187,500	-48,500	
1979	139,000	204,000	-65,000	
1980	139,000	225,000	-86,000	
1981	139,000	247,000	-108,000	

TABLE VII-51 - DEPENDABLE SYSTEM CAPACITY TO MEET PEAK DEMAND VERSUS SYSTEM COINCIDENTAL PEAK DEMAND AT PLANT--1968-1980 (CASE B)

Year	Dependable system capacity (kw.)	System coincidental peak demand (kw.)	Surplus (+) or deficit (-) (kw.)	
1966	65,000	36,200	+28,800	37-mw. Awash No. 2 added
1967	65,000	43,300	+21,700	
1968	102,000	51,600	+50,400	37-mw. Awash No. 3 added
1969	102,000	62,000	+40,000	
1970	102,000	72,800	+29,800	
1971	139,000	82,600	+56,400	37-mw. Awash No. 4 added
1972	139,000	94,300	+44,700	
1973	139,000	107,300	+31,700	
1974	139,000	121,600	+17,400	
1975	139,000	135,600	+3,400	
1976	139,000	152,100	-13,100	
1977	139,000	188,800	-49,800	
1978	139,000	210,900	-71,900	
1979	139,000	230,000	-91,000	
1980	139,000	255,000	-116,000	

264

The Awash River has advantages in that it is generally closer to the principal load centers, but the development of the three or four hydroelectric installations there will depend primarily upon the Koka reservoir for regulation. Whether Awash No. 4 is developed or not would depend somewhat upon the time that it would take to bring the Finchaa plant into production.

In this study, it is assumed that the Finchaa plant would not be brought into production during the year 1971. Assuming three years for construction, final construction would have to begin in 1968. Allowing at least two to three years for feasibility studies, another year for final design, and possibly a year at least for slippage, work would have to start immediately on the feasibility surveys and studies. While it might be possible to get Finchaa into production during 1971, the extra time allowed by constructing Awash No. 4 has been used.

It should be recognized that constructing four hydroelectric powerplants cascaded on one river (Awash), regulated by one reservoir and constituting 95 percent of the utility electrical energy source for the heart of the Empire, may not be the most desirable situation. This is especially true when one considers leakage problems associated with the one reservoir and the yet unknown consequences of reservoir sedimentation and evaporation at Koka. Therefore, every effort should be made to develop other hydroelectric facilities as soon as possible in another river basin conveniently located near Addis Ababa. The Finchaa Sub-Basin powerplants offer a good solution to the problem, and at the same time the other aspects of the multiple-purpose projects will be highly beneficial to the economy.

Therefore, if possible, consideration should be given to expediting preconstruction activities on the Finchaa Sub-Basin so that the Finchaa power facilities can be placed into operation when needed following Awash No. 3. However, this may not be possible and, as explained, Awash No. 4 may be required.

Future deficiencies in the power supply for both Cases A and B can be met by the Finchaa Sub-Basin powerplants, together with the four Awash plants, for some time into the future, perhaps to the year 1980 or 1981 even at an optimistic rate of load growth. This is illustrated by Tables VII-52 and VII-53 for Cases A and B, respectively. The Interconnected System, as it will appear (Case A or B) in 1971, is shown on Drawing No. 4.0-Et-14.

26

TABLE VII-52 - ESTIMATED FUTURE NEEDS FOR ADDITIONAL CAPACITY USING FINCHAA SUB-BASIN FACILITIES--1968-1980 (CASE A)

Year	Dependable system capacity (kw.)	System coincidental peak demand (kw.)	Surplus (+) or deficit (-) (kw.)	New generating facilities
1966	65,000	36,200	+28,800	37-mw. Awash No. 2 added
1967	65,000	43,300	+21,700	
1968	102,000	51,600	+50,400	37-mw. Awash No. 3 added
1969	102,000	62,000	+40,000	
1970	102,000	72,200	+29,800	
1971	139,000	82,600	+56,400	37-mw. Awash No. 4 added
1972	139,000	94,300	+44,700	
1973	139,000	107,300	+31,700	
1974	219,000	119,100	+99,900	80-mw. Finchaa added
1975	219,000	134,100	+84,900	
1976	219,000	150,400	+68,600	
1977	219,000	169,000	+50,000	
1978	299,000	187,500	+111,500	80-mw. Neshe added
1979	299,000	204,000	+95,000	
1980	299,000	225,000	+74,000	
1981	299,000	247,000	+52,000	

2

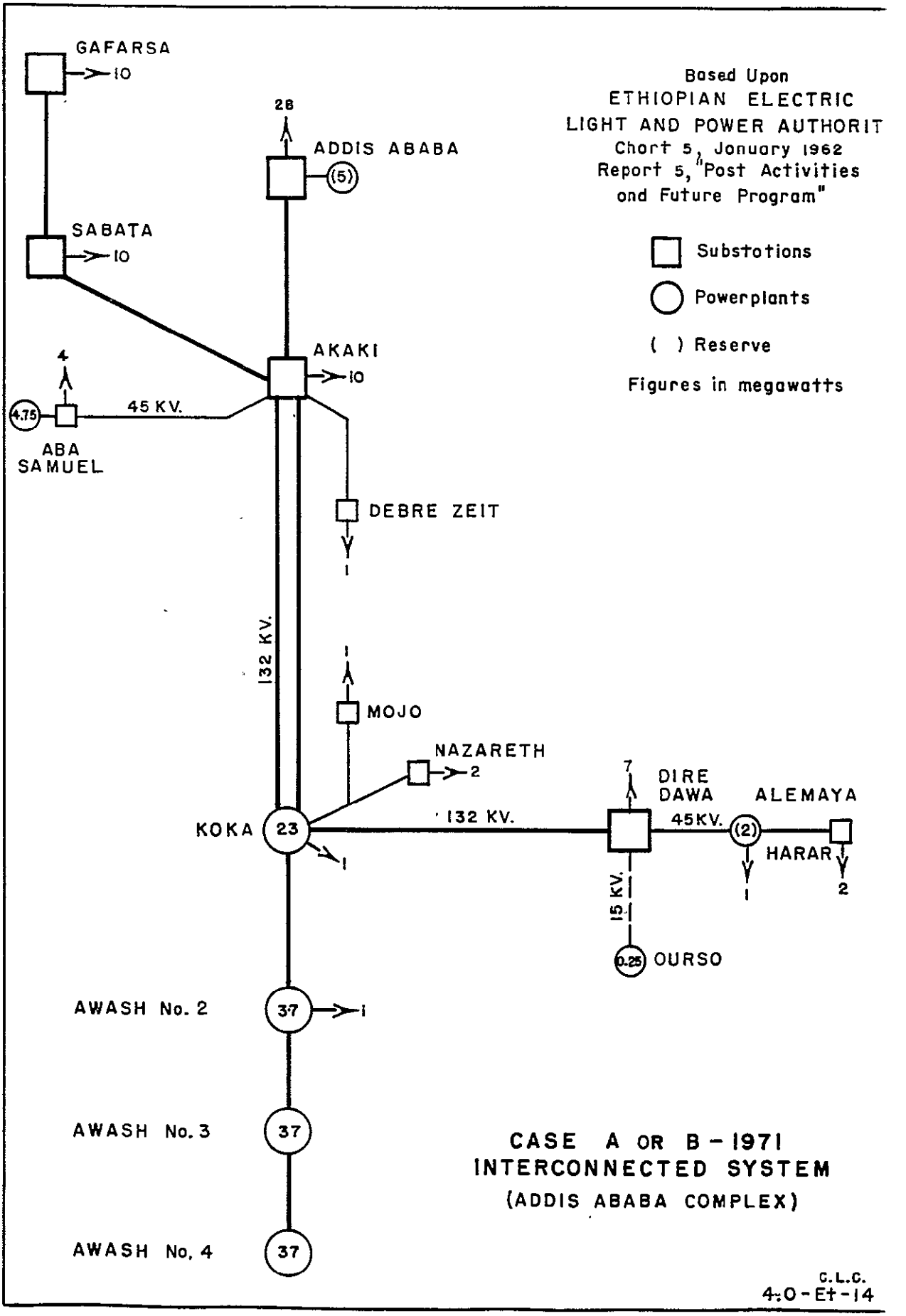
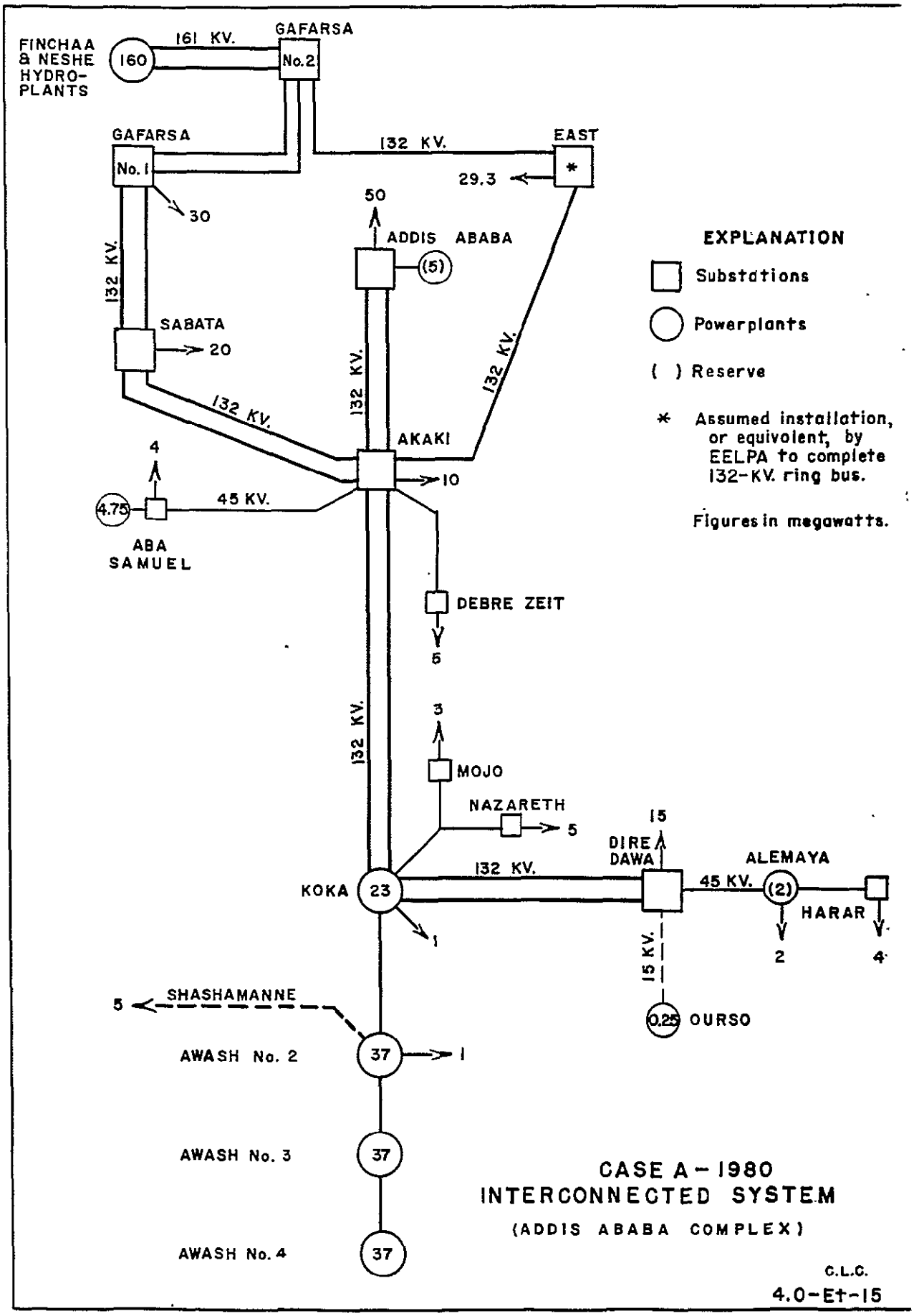
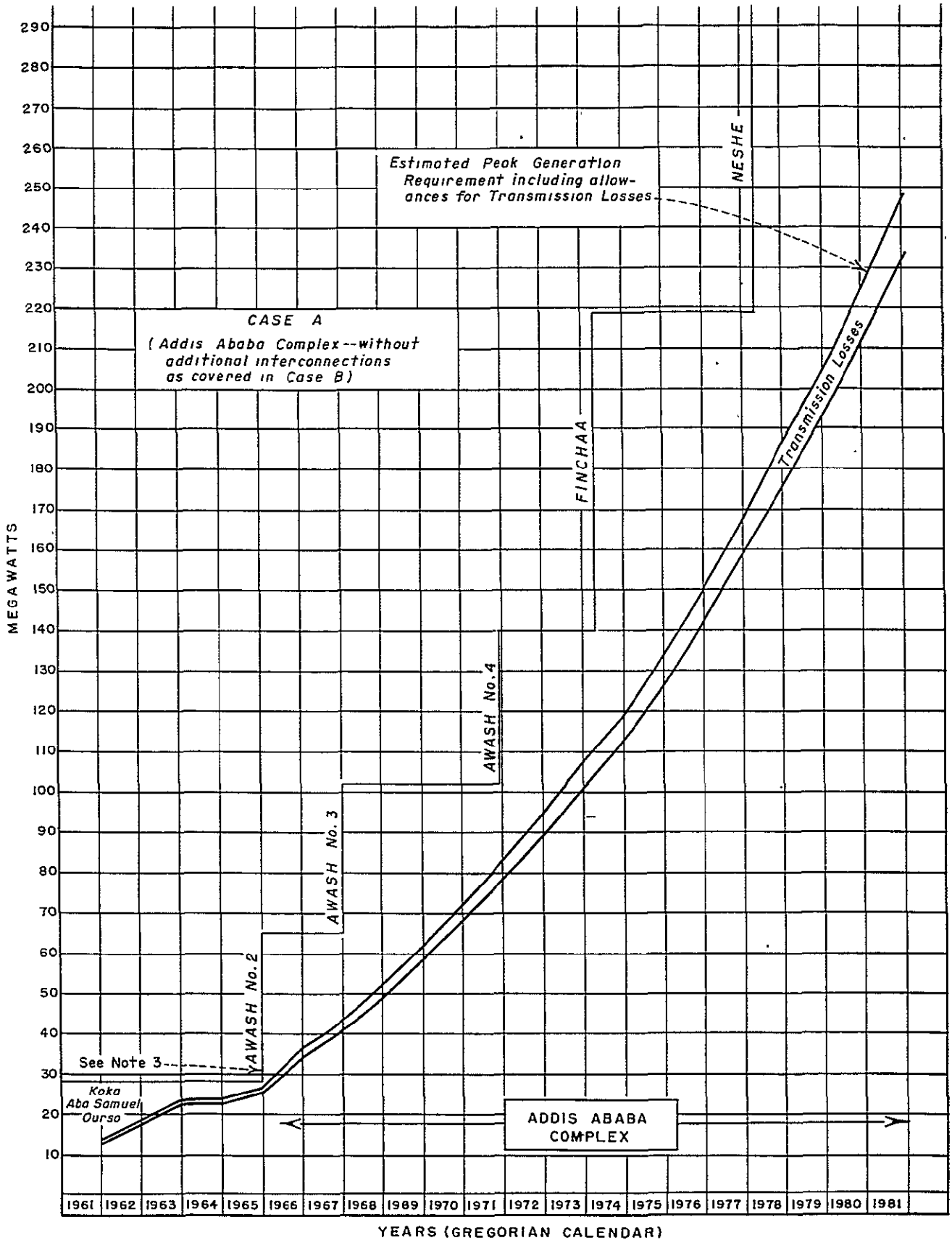

GAFARSA
10
28
ADDIS ABABA
(5)
SABATA
10
AKAKI
10
4
4.75
45 KV.
ABA SAMUEL
DEBRE ZEIT
1
132 KV.
1
MOJO
NAZARETH
2
7
DIRE DAWA
ALEMAYA
KOKA
23
132 KV.
45KV.
(2)
HARAR
1
2
1
15 KV.
0.25
OURSO
AWASH No. 2
37
1
AWASH No. 3
37
AWASH No. 4
37
Based Upon
ETHIOPIAN ELECTRIC
LIGHT AND POWER AUTHORIT
Chart 5, January 1962
Report 5, "Post Activities
and Future Program"
Substations
Powerplants
( ) Reserve
Figures in megawatts
CASE A OR B - 1971
INTERCONNECTED SYSTEM
(ADDIS ABABA COMPLEX)
G.L.C.
4-0-Et-14

TABLE VII-53 - ESTIMATED FUTURE NEEDS FOR ADDITIONAL CAPACITY USING FINCHAA SUB-BASIN FACILITIES--1968-1980 (CASE B)

Year	Dependable system capacity (kw.)	System coincidental peak demand (kw.)	Surplus (+) or deficit (-) (kw.)	New generating facilities
1966	65,000	36,200	+28,800	37-mw. Awash No. 2 added
1967	65,000	43,300	+21,700	
1968	102,000	51,600	+50,400	37-mw. Awash No. 3 added
1969	102,000	62,000	+40,000	
1970	102,000	72,200	+29,800	
1971	139,000	82,600	+56,400	37-mw. Awash No. 4 added
1972	139,000	94,300	+44,700	
1973	139,000	107,300	+31,700	
1974	219,000	121,600	+97,400	80-mw. Finchaa added
1975	219,000	135,600	+83,400	
1976	219,000	152,100	+66,900	
1977	219,000	188,800	+30,200	
1978	299,000	210,900	+88,100	80-mw. Neshe added
1979	299,000	230,000	+69,000	
1980	299,000	255,000	+44,000	


FINCHAA & NESHE HYDRO-PLANTS
160
161 KV.
GAFARSA
No.2
GAFARSA
No. 1
30
132 KV.
EAST
*
29.3
50
ADDIS ABABA
(5)
132 KV.
SABATA
20
132 KV.
132 KV.
132 KV.
AKAKI
10
4
4.75
45 KV.
ABA SAMUEL
DEBRE ZEIT
5
132 KV.
3
MOJO
NAZARETH
5
15
DIRE DAWA
132 KV.
ALEMAYA
45 KV.
(2)
HARAR
KOKA
23
1
2
4
15 KV.
0.25
OURSO
5
SHASHAMANNE
AWASH No. 2
37
1
AWASH No. 3
37
AWASH No. 4
37
EXPLANATION
Substations
Powerplants
( ) Reserve
* Assumed installation, or equivalent, by EELPA to complete 132-KV. ring bus.
Figures in megawatts.
CASE A - 1980
INTERCONNECTED SYSTEM
(ADDIS ABABA COMPLEX)
C.L.C.
4.0-Et-15



NOTES:

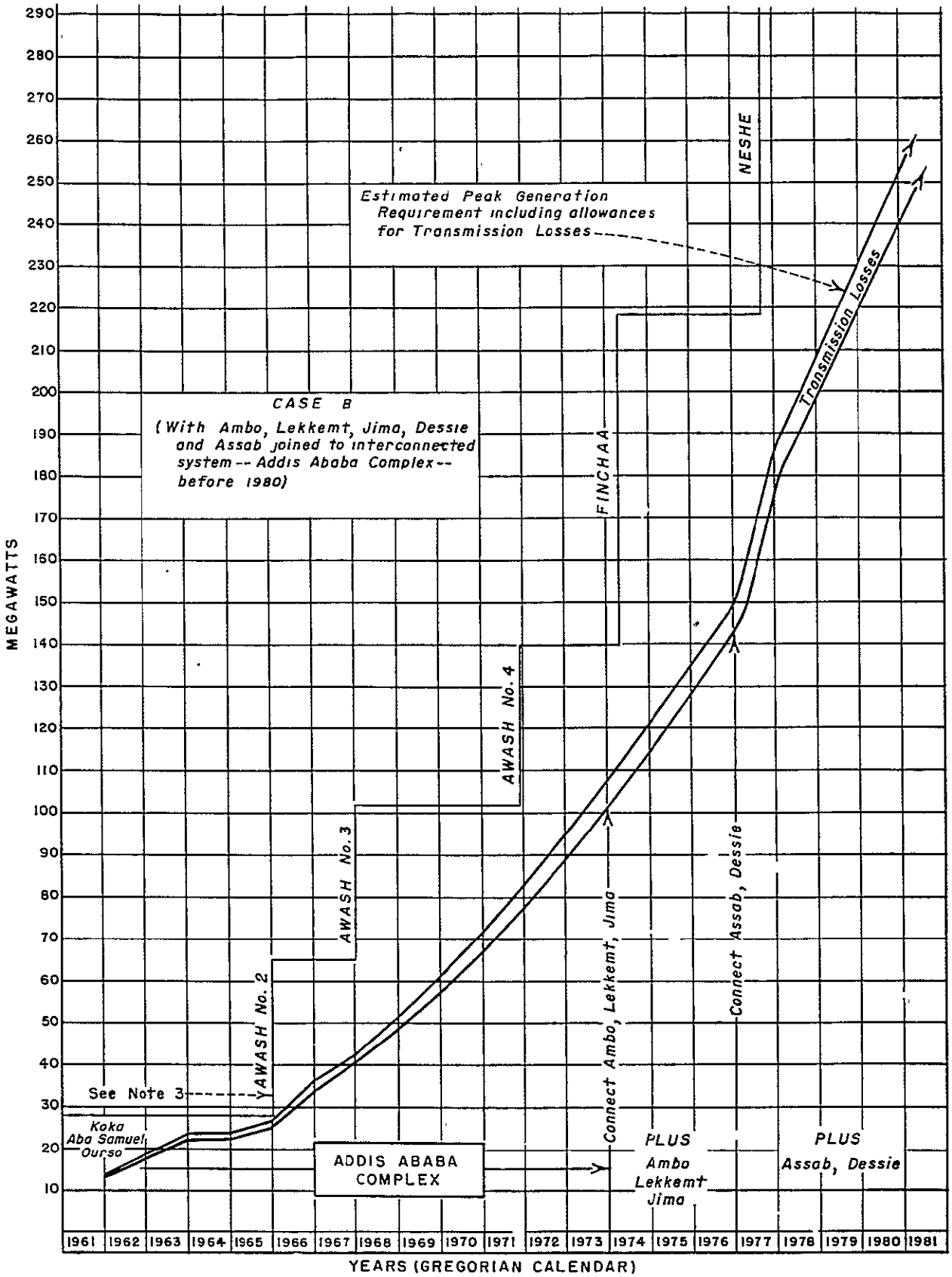
1. Designs completed in 1963 for Awash Powerplants No's. 2 and 3, with construction to start in early 1964.
2. One Megawatt = 1000 Kilowatts.
3. 7 mw thermal plus 11.5 mw from hydro (Koka 3rd Unit in adverse water year) available as reserves in addition to that included above

BLUE NILE PROJECT
ESTIMATED PEAK GENERATION REQUIREMENTS AND SCHEDULE OF POWERPLANT INSTALLATIONS
CASE A
INTERCONNECTED SYSTEM

4.0-BN-172

C.L.C.

272



NOTES:

1. Designs completed in 1963 for Awash Powerplants Nos. 2 and 3 with construction to start in early 1964.
2. One Megawatt = 1000 Kilowatts.
3. 7 mw thermal plus 11.5 mw from hydro (Koka 3rd. Unit in adverse water year) available as reserve in addition to that included above.

BLUE NILE PROJECT
ESTIMATED PEAK GENERATION REQUIREMENTS AND SCHEDULE OF POWERPLANT INSTALLATIONS
CASE B
INTERCONNECTED SYSTEM

4.0-BN-173

C.L.C.

2

probable single-line diagram of the Interconnected System as it may exist in 1980, Case A only.

Estimated Power Costs of Alternative Sources

Direct power benefits as discussed in SECTION VIII can be measured by the lesser of two figures--the estimated cost of the most economical alternative source of equivalent power likely to be developed in the market area in the absence of either of the projects in the Finchaa Sub-Basin, or the estimated value of power to the users in cases where an alternative to Finchaa Sub-Basin plants may not exist or where alternative costs would exceed the maximum rates at which the power could be marketed. The alternative source most likely to be developed is an oil-fired, steam-electric powerplant located near the principal load center, Addis Ababa. The estimated power costs of alternative sources are obtained first for the Finchaa powerplant and second for the Neshe powerplant.

Although the installed capacity may be the same (80 mw.) for both the Finchaa and Neshe plants, the Neshe plant is capable of slightly greater annual energy generation than is the Finchaa.

Finchaa Hydroelectric Powerplant and Related Facilities

Equivalent Steam Plant at Akaki--Size and Description of Facilities. The Finchaa powerplant can deliver to the Addis Ababa load center a maximum of 343,692,000 kw.-hr. in an adverse water year, allowing for losses and system use. For an equivalent steam-electric plant located on the Aba Samuel Reservoir near Akaki (see Dwg. No. 4.0-BN-85) to deliver the same amount of energy to the same area as the Finchaa hydro, the Akaki steam plant would have to be capable of generating 365,436,000 kw.-hr. (gross) per year. This considers delivery at the same voltage, considers all losses, and also considers the much larger (five percent of gross) plant requirements for own use. The equivalent steam plant capacity would be 83.4 mw. The following characteristics were assumed.

Millions of B.t.u. per hour	=	433
Superheat temperature	=	950° F.
Operating pressure	=	1,360 p.s.i.g.

Steam Plant and Related Facility Construction Costs. Using steam plant boiler and generating facility cost curves developed for Ethiopia, the following costs were arrived at.

Boiler Plant	Eth$6,500,000
Generating facilities	25,000,000
Subtotal	Eth$31,500,000 (Eth$394/kw. or US$158/kw.)
Spur railroad, 7 km. long	441,000
Access road, 2-lane, gravel, 7 km.	464,000
Switchyard cost at steam plant	3,769,000
Transmission lines, 2 each, 132-kv., 28 km.	2,352,000
Receiving-end substation (switching only)	1,218,000
Total	Eth$39,744,000

Annual Operation and Maintenance Costs. Fuel costs (furnace oil) will be substantial, as this is an imported item. The fuel has been assumed to have 40,700 B.t.u./kg. and costs Eth$128/metric ton, based upon fuel costs for the Addis Ababa steam plant. A total of 93,292 metric tons of fuel oil would be required per year, costing Eth$11,941,376. The following costs were arrived at.

Fuel costs	Eth$11,941,376
O&M including lubrication oils	1,200,000
Road and railroad	11,000
Transmission lines and substation	35,000

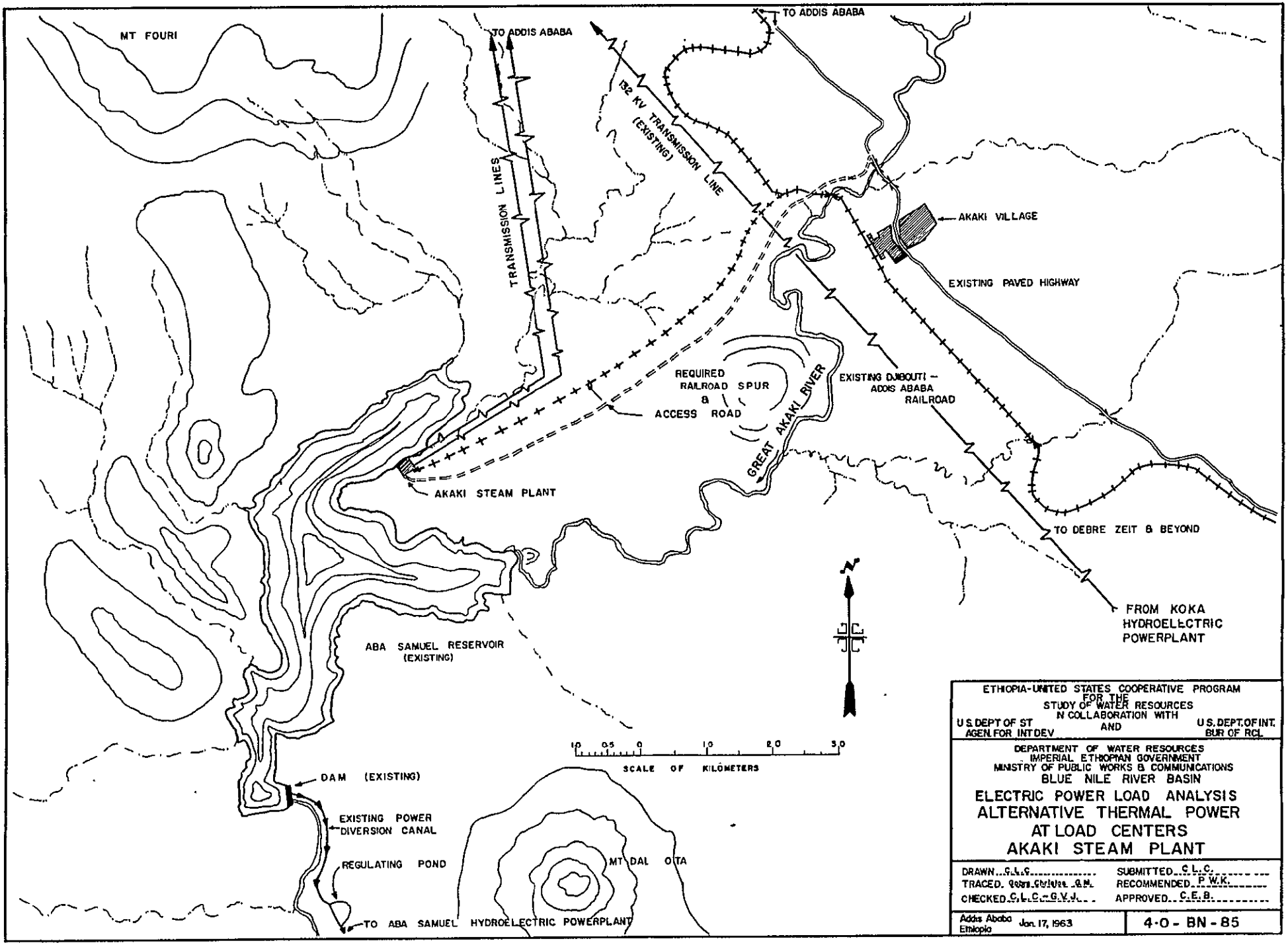
Annual Fixed Costs. The present government-owned authority, EELPA, pays a substantial tax each year to governmental units. The amount used here is not intended to reflect the same tax rate but is used for both the hydro facilities and their alternatives.

Taxes and insurance	Eth$124,427
Replacement reserve, all facilities	697,569
Amortization	2,394,763

Annual replacement costs were computed on the basis of five percent for 50 years, using service lives estimated to reflect conditions in Ethiopia. This included a service life of 25 years for the steam plant.

Amortization was based upon a five percent interest rate at 50 years and also included amortizing the cost of interest during construction, amounting to Eth$3,974,400.

27


MT FOURI
TO ADDIS ABABA
TO ADDIS ABABA
132 KV TRANSMISSION LINE (EXISTING)
TRANSMISSION LINES
AKAKI VILLAGE
EXISTING PAVED HIGHWAY
REQUIRED RAILROAD SPUR & ACCESS ROAD
GREAT AKAKI RIVER
EXISTING DJIBOUTI - ADDIS ABABA RAILROAD
AKAKI STEAM PLANT
TO DEBRE ZEIT & BEYOND
FROM KOKA HYDROELECTRIC POWERPLANT
ABA SAMUEL RESERVOIR (EXISTING)
N
1.0 0.5 0 1.0 2.0 3.0
SCALE OF KILOMETERS
DAM (EXISTING)
EXISTING POWER DIVERSION CANAL
REGULATING POND
MT DAL OTA
TO ABA SAMUEL HYDROELECTRIC POWERPLANT
ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH AND
U.S. DEPT OF ST AGEN. FOR INT DEV
U.S. DEPT. OF INT. BUR OF RCL
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN
ELECTRIC POWER LOAD ANALYSIS
ALTERNATIVE THERMAL POWER
AT LOAD CENTERS
AKAKI STEAM PLANT
DRAWN C.L.C.
TRACED
CHECKED C.L.C. G.V.J.
SUBMITTED C.L.C.
RECOMMENDED P.W.K.
APPROVED C.E.B.
Addis Ababa Ethiopia Jan. 17, 1963
4-0 - BN - 85

Summary of Annual Costs. All annual costs can be summarized as shown below.

Operation, Maintenance, and Replacement	
Fuel costs	Eth$11,941,376
O&M steam plant, lines, substations	1,235,000
Road and railroad maintenance	11,000
Replacement reserve	697,569
Subtotal	Eth$13,884,945
Amortization	2,394,763
Other (taxes and insurance)	124,427
Total steam alternative	Eth$16,404,135
rounded to	Eth$16,400,000

Cost of Alternative Energy. Cost of energy at the same load point as that from Finchaa hydroplant is as follows:

$$\frac{\text{Eth\$16,400,000}}{\text{343,692,000 kw.-hr./yr}} = \text{Eth4.77¢/kw.-hr. (US1.91¢/kw.-hr.)}$$

(Note: Eth4.72¢/kw-hr. at busbar, steam plant.)

Neshe Hydroelectric Powerplant and Related Facilities

Equivalent Steam Plant at Akaki (Acachi). Neshe facilities from the Finchaa Sub-Basin will follow some time after completion of the Finchaa powerplant. Its alternative source at load center is also a steam plant located at Akaki, as shown by Drawing No. 4.0-BN-85.

Size and Description of Facilities. The Neshe powerplant can deliver to the Addis Ababa load center a maximum of 360,457,000 kw.-hr. in an adverse water year, allowing for losses and system use. To deliver the same amount of energy to the same area as the Neshe powerplant, the Akaki steam plant would have to be capable of generating 383,263,000 kw.-hr. (gross) per year. This also considers delivery at the same voltage, considers all losses, and considers the larger plant requirements needed by steam electric powerplants (five percent of gross) for its own use.

The equivalent steam plant capacity would be 87.5 mw., and the plant would have the following assumed characteristics.

Millions of B.t.u. per hr.	=	455
Superheat temperature	=	950° F.
Operating pressure	=	1,360 p.s.i.g.

Steam Plant and Related Facility Construction Costs. The following costs have been arrived at.

Boiler plant	Eth$6,800,000
Generating facilities	26,000,000
Subtotal	Eth$32,800,000
	(Eth$375/kw. or US$150/kw.)
Spur railroad, 7 km. long	441,000
Access road, 2-lane, gravel, 7 km.	464,000
Switchyard cost at steam plant	3,769,000
Transmission lines, 2 each, 132 kv., 28 km.	2,352,000
Receiving-end substation (switching only)	1,218,000
Total	Eth$41,044,000

Annual Operation and Maintenance Costs. The same assumptions regarding fuel were made here as were used for the Finchaa Project study. However, a total of 97,957 metric tons would be required per year, costing Eth$12,538,500.

Annual operation and maintenance costs are estimated as follows.

Fuel	Eth$12,538,500
O&M including lubrication oils	1,200,000
Road and railroad	11,000
Transmission lines and substation	35,000

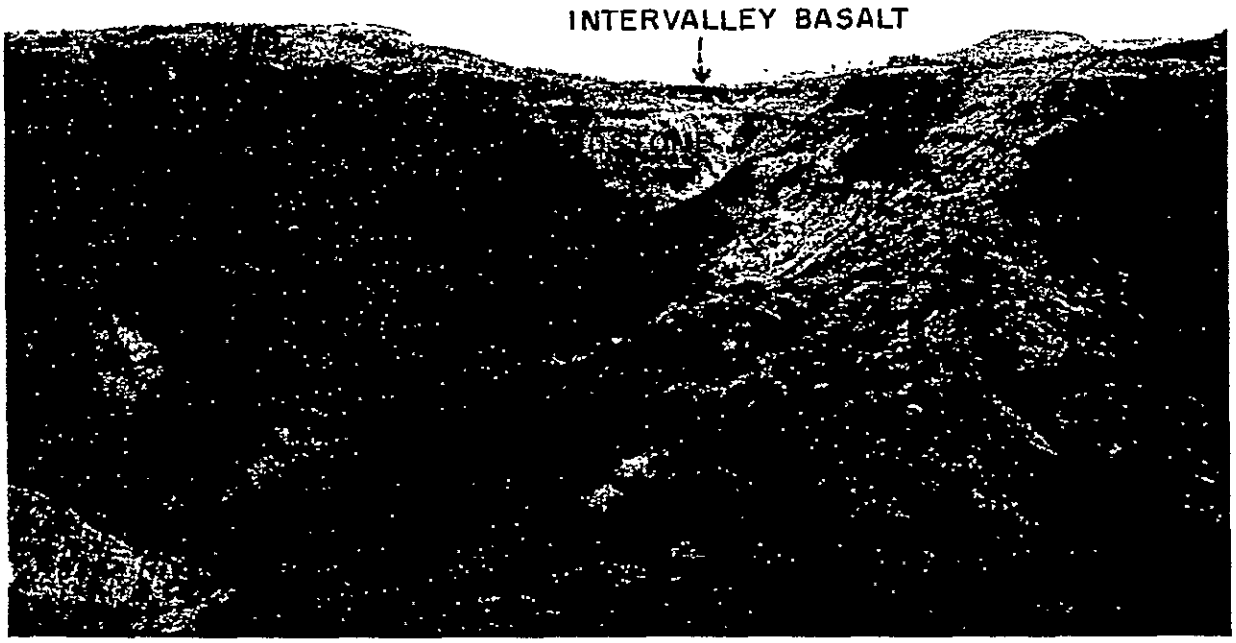
Annual Fixed Costs. Costs falling into this category were estimated as shown below.

Taxes and insurance	Eth$128,976
Replacement reserve, all facilities	724,869
Amortization	2,473,094

Summary of Annual Costs. Total annual costs can be summarized as shown in the following tabulation.

Operation, maintenance, and replacement	
Fuel costs	Eth$12,538,500
O&M steamplant, lines, substations	1,235,000
Road and railroad maintenance	11,000
Replacement reserve	724,869
Subtotal	Eth$14,509,369
Amortization	2,473,094
Other (taxes and insurance)	128,976
Total steam alternative	Eth$17,111,439
rounded to	Eth$17,110,000

27



NESHE POWERPLANT SITE – AMARTI – NESHE PROJECT

Cost of Alternative Energy. The cost of energy at the same load point as that from the Neshe hydroelectric powerplant is shown below.

$$\frac{\text{Eth\$17,110,000}}{\text{360,457,000 kw.-hr./yr}} = \text{Eth4.75¢/kw.-hr. (US1.90¢/kw.-hr.)}$$

(Note: Eth4.70¢/kw.-hr. at busbar, steam plant.)

Summary

The average cost of steam electric generating stations in the United States in 1960 was US$152.50 per installed kilowatt of capacity, 1/ exclusive of switchyard. The busbar energy cost averaged US0.69¢ per kilowatt-hour for all stations. This compares with the steam alternative for the Finchaa powerplant as follows:

Cost of installed capacity	US$158/kw.
Cost of energy at busbar	US$.0189/kw.-hr.

The cost of energy from Akaki steam plant would range from 1.4 to about 2.0 times that in the United States, while the cost per installed kilowatt is comparable, based upon a European plant installed at Akaki. The high energy cost is largely attributed to higher fuel costs.

1/ Electrical World, 12th Steam Station Cost Survey, Oct. 2, 1961.

279

SECTION VIII - ECONOMIC ANALYSIS

FINCHAA PROJECT

Benefits

Irrigation. Annual irrigation benefits of the Finchaa Project are expected to be Eth$8,936,000 under full development conditions. The gross crop method of analysis shows the the Finchaa Project has an expected annual post-project income of Eth$595.70 per hectare. There is no pre-project income, so the increased income arising from project development is the same Eth$595.70. Applied to the full project, the gross income is approximately Eth$8,936,000 annually.

This figure represents the gross value of crops expected to be produced in a single year under full development, assuming the stated crops, prices, and yields. Farm costs have not been deducted from this gross return, due to the lack of reliable and valid data. Consequently, the Eth$8,936,000 figure exceeds the net return to irrigation. It includes the direct benefits, which apply to the project area, and the indirect benefits, which apply to the economy outside the project.

Benefits from irrigation arise at the farm or project level, but are not confined there. Any farm expense, whether labor, supplies, or machine operation, represents farm costs, but creates a monetary benefit to the supplier of the goods or service. Benefits are widespread, since the purchase of a single item may involve not only the local retailer and wholesaler, but possibly a jobber and importer. Sales of farm products create a similar type of chain reaction.

To measure these indirect benefits, as well as the direct benefits where farm costs can neither be measured nor predicted accurately, the "gross crop income" method is used. Gross returns are computed for farming operations, under full development conditions, and represent the value of the irrigation project to the country as a whole. They are compared to the annual equivalent costs of the irrigation project, in a benefit-cost ratio.

Project labor will receive a large share of the benefits, since field labor, excluding farmers, will be required at the probable rate of one man per hectare. Benefits accruing to the dealers who handle, process, and market the crops, and to those who supply goods and services needed on the project, make up another large component. And still another monetary benefit will be the profits to farmers and to the project.

Many nonmonetary benefits will arise as a result of project development. The improvements in housing and diet, in sanitary and medical facilities, the increased opportunity to educate the children, the beginning of a rural land market, and the chance to acquire and practice new skills are important. But most important will be the creation of a class of independent, capable, commercial farmers. This is the final goal of the Finchaa Project and is probably the greatest single benefit that will be attributed to irrigation project development in Ethiopia.

No precise measurement of tax benefits to the national treasury is presented, but the pattern of levying taxes on agricultural projects in Ethiopia is well established. Therefore, a portion of the gross income would be paid in taxes each year. The amount could be known only after operations had commenced and governmental policy regarding land taxes and tithes, health and education taxes, and taxation of wages and private income had crystallized.

The effect of the investment on the Ethiopian economy should not be overlooked. Although plans regarding the source and amount of foreign and local capital are not yet formulated, certainly a major part of the capital would be of foreign origin. Construction of the multiple-purpose Finchaa Project will exceed Eth$91,000,000; the effect of a sum of this magnitude on the Ethiopian economy will be enormous.

Both the positive and the negative effects of this input of capital must be considered. Positive effects can take the form of increased demand and employment; negative effects, the form of inflation or the withholding of scarce physical resources from other segments of the economy during the construction period.

For any irrigation project there is a period between the initiation of development of project lands and full project development. This period, called a "lag," is of uncertain duration for the Finchaa Project, or indeed for any irrigation project in Ethiopia. Many questions regarding the rate of growth remain unanswered. But until full benefits are realized, the project cannot produce Eth$8,936,000 in gross crop value annually.

To offset the period before full project benefits are realized, a conservative approach is used for crop yields and land utilization. Yield figures are based upon similar irrigated areas and adjusted for the Finchaa valley. But they have not been projected upward for the future. Since commercial crops are constantly being improved, new varieties developed, and better techniques adapted, it is reasonable to assume that yields would be higher in the future. This is especially true because an experimental farm is planned for every irrigation project. If yields increase, monetary returns would be higher.

The cropping pattern projects only one planting of each crop per irrigation season. This also understates future income, since fuller utilization of project lands is probable after operations have become well established.

Consequently, ultimate crop income may well exceed the Eth$8,932,000 figure. This would tend to offset the early period when less than full returns were realized. It is probably more justifiable to assume that income greater than Eth$8,932,000 will be achieved toward the end of the development period, to balance or offset the early years when less was realized, than it is to attempt to predict the duration and the extent of the lag.

The contribution of the Finchaa Project to the gross national economy of Ethiopia should be considered. The G.N.P. of Ethiopia is expected to reach Eth$2,400,000,000 1/ by 1964. Under ultimate development the Finchaa Project should contribute Eth$25,336,000 yearly. Although the figures are not strictly comparable due to the lag in development and the techniques of computing irrigation and power benefits, still a contribution of this size would be significant to the agricultural, agricultural processing, electric power, and the manufacturing sectors of the economy.

Power. Two broad categories of power benefits are used: direct, and indirect and intangible. Direct power benefits are evaluated in monetary terms and comprise the only category used in this study to evaluate benefits when comparing with costs to arrive at a benefit-cost ratio. Indirect and intangible benefits, although very important, have not been evaluated in monetary terms in this study and hence are not included in the total annual monetary benefit used to compare with costs.

Direct power benefits are the values placed on the supplies of electric power and energy delivered at wholesale prices to municipalities, federal agencies, or privately owned public utilities. For this study, it could be the value placed on delivery to the EEIPA at Addis Ababa.

1/USAID/Ethiopia, 1962.

In principle, the value or benefit of this service is the market price that EELPA would pay for designated amounts of particular classes of power and energy at specific times and points of delivery. In practice, direct power benefits are measured by the lesser of two figures--the estimated cost of the most economical alternative source of equivalent power likely to be developed in the market area in the absence of the project, or the estimated value of power to the users in cases where an alternative to IEG project development may not exist or where alternative costs would exceed the maximum rates at which the power could be marketed. For this study, it was determined that the alternative source of equivalent power would be an oil-fired steam plant located near Addis Ababa at Akaki. (See SECTION VII.) Direct power benefits by this method are estimated at Eth$16,400,000 annually. Power benefits may be realized at downstream powerplants as a result of planned water releases upstream. In this study, there are no existing downstream plants, but these may develop in the future.

Indirect and intangible power benefits, although not measured in monetary terms, occur by virtue of the existence and operation of the project features. For the Finchaa Sub-Basin Projects, these intangible benefits are as follows:

1. Effectuation of greater dependability and continuity of power service through the integration and coordination of Finchaa Sub-Basin powerplants with the Awash powerplants.

2. Contribution to effective industrial, commercial, and urban development to help achieve the national goal of transforming the present agricultural economy to an agricultural-industrial economy by 1982.

3. The making available of larger blocks of power useful in a national emergency, and so contributory to national security.

4. Conservation of foreign exchange by reduction of the need for importation of fossil fuels.

Some indirect benefits resulting from the construction of the Finchaa Sub-Basin Projects are as follows:

1. Sedimentation control. In the future, other reservoirs may be constructed downstream on the Blue Nile River, and in some small measure the Finchaa Project reservoirs will contribute toward the prolongation of the useful lives of downstream reservoirs, resulting in the extension of the power and other benefits that they may provide.

2. Fish and wildlife conservation. Ultimately, the reservoirs, when planted with the proper species, may provide a good source of fish to supplement the diets of the local people or even produce enough to warrant commercial development. The existing swamps produce no fish at present.

Of the indirect and intangible benefits, the contribution of the projects toward developing the industrial, commercial, and urban segments of the economy may be considered the most important. In a country which has no local supply of oil, coal, or other economical source of energy in commercial quantities, the necessity to import large quantities of fuel provides a deterrent to large scale development. Not only is imported fuel costly to use, but the import expenses can place a severe load on the economy which has to provide sufficient exports to meet the bill.

Ethiopia, with the establishment of the Koka dam and with continued additions to the hydroelectric power supply, including the Finchaa and Amarti-Neshe facilities, will solve the industrial fuel problem by providing for its own domestic source of power. It has or can obtain the other means of industrial production--labor, materials, and enterprise--although the latter is perhaps in short supply now.

Diversification of the economy, placing greater emphasis on industrialization, can form a basis for permanent improvement of living standards, in turn resulting in better health, education, and per capita income. The stimuli to industrialization provided by ample hydroelectric supplies are three:

1. By reducing initial costs of power installations and the total cost of providing power during the lifetime of any particular industrial concern.

2. By providing sufficient quantities of power, as and when required.

3. By providing flexibility in use of electricity as opposed to other forms of power.

The beneficial effects of industrialization as they apply to Ethiopia may be summarized as follows:

1. Greater use is made of Ethiopia's own resources so that a higher proportion of the final value of the country's products can be retained in the country, reducing imports.

28

2. A new class of artisans will be created which, in turn, necessitates and brings about a gradual improvement in educational standards. The new conditions of working and earning encourage the raising of living standards by giving the people incentives to own material things.

Costs

Construction. Construction costs for the multiple-purpose Finchaa Project, excluding land development costs, are Eth$86,127,000. These include Eth$16,112,000 for the irrigation facilities, Eth$65,177,000 for the power facilities, and Eth$4,838,000 for the joint-use facilities. Land development costs are Eth$5,325,000 and bring total construction and development costs to Eth$91,452,000. Construction costs are amortized over a fifty-year period at five percent interest.

Interest during Construction. Interest during the construction period is an economic cost of the Finchaa Project. It represents the cost of borrowing the funds required during the four- or five-year period of construction, preceding the fifty-year period of project operations. Benefits are calculated for the fifty years following construction, but the cost of borrowing the money before benefits are realized must be included to make the ratio of benefits to costs as complete as possible.

Simple interest is charged on monies borrowed to construct the project, and is amortized over the fifty-year period of analysis at five percent. Five years are required to construct the irrigation facilities, four years for the power and joint-use facilities.

Total interest during construction is Eth$9,015,500 (Eth$9,016,000). This includes Eth$2,014,000 for irrigation, Eth$6,517,700 for power, and Eth$483,800 for the joint-use facilities.

Development Costs. Land development constitutes two factors--land clearing and land leveling. The Finchaa Project area lies in the tropical savannah classification of Ethiopian forest and supports a heavy growth on the land. Clearing costs are expected to approximate Eth$230 per hectare, or Eth$3,450,000 for the entire project.

The land is moderately gentle to rolling, and leveling costs are expected to be Eth$125 per hectare, or Eth$1,875,000 for the project. Therefore, total land development costs should be Eth$5,325,000 for the project, or Eth$292,000 per year when amortized over the fifty-year period of analysis at five percent interest.

28

Operation, Maintenance, and Replacement Costs. Personnel expenses for operation, maintenance, and replacement of the Finchaa Project are expected to be about Eth$255,000 per year. Costs for equipment, supply, and general expenses should average Eth$285,000. Therefore, yearly costs for the irrigation function of the Finchaa Project should be Eth$540,000 annually. In addition, Eth$48,000 will be required yearly for operation, maintenance, and replacement of the portion of the joint-use facilities allocated to irrigation. Total costs then would be Eth$588,000 per year.

Other Costs. In addition to the construction, interest during construction, land development, and operation, maintenance, and replacement costs, still other costs exist for which no accounting is made in this reconnaissance study. These include the costs of constructing roads from the nearest highway into the project area, eradicating the present and potential diseases which make human life hazardous in the valley, acquiring the lands for project use, and the costs which are associated with land settlement.

A highway exists from Addis Ababa through the village of Gedo, the closest point to the Finchaa Project area. A trail north from Gedo to the hamlets of Shambo and Haratu is not usable for heavy hauling, nor does it extend to the Finchaa valley.

Although access roads are planned as costs of the project, these will cover only the distance from the edge of the escarpment to the lower end of the project. Therefore, a road is required from Gedo to the escarpment edge, a distance of some 60 to 70 kilometers. The construction, which would involve considerable cost to the government, would probably be delegated to the Imperial Highway Authority.

At present the valley is uninhabited; this is thought to be because animal and human diseases make the area unsafe for life and livelihood. Cattle diseases are less important, because stock will be kept only on a small scale (see "Livestock"). Nevertheless, animal health should be considered by the Ministry of Agriculture. Human disease is a paramount problem. The Anopheles mosquito and the Glossina tsetse fly make vector control necessary. And equally important is the danger of bilharziasis, a disease which does not now exist in the Finchaa valley. Bilharziasis or schistomiasis is a water-borne sickness which tends to follow the introduction of irrigation in Africa. The disease is caused by a group of blood flukes (Schistosoma species) and is carried by certain fresh-water snails (Bulinus or Physopsis species). Control of the snails is essential, and they appear to thrive in such shallow watery areas as irrigation canals and ditches. Costs of combating bilharziasis, other water-borne diseases, and injurious insects may be high for irrigation projects. Cooperation with the Ministry of Health is essential.

No costs have been assigned for the acquisition of project lands. Inasmuch as the Finchaa valley is unoccupied, no major expenses should be involved, although the local people living in the Chomen Swamp may claim ownership of the land.

Settlement costs and social and technical services are not included. A permanent camp is planned, but this is not intended to house farmers or laborers. Costs involved in moving people into the area and providing them the necessities until they can become self-supporting will require consideration in a detailed study. The cost of educating the children, providing sanitation systems and other social overhead services, and paying the agricultural, engineering, and health education specialists should be considered later. Each of these costs, whether for road construction, disease control, or acquiring and settling land, is real and must be considered when a final evaluation of the Finchaa Project is made. The sum of all costs should be measured against expected benefits to develop a more refined benefit-cost ratio, and to present precise financial data when a project loan is requested.

Annual Cost Equivalents. To determine the ratio of benefits to cost for the multiple-purpose Finchaa Project, annual equivalent costs are compared to annual benefits. Table VIII-1 summarizes the costs on a fifty-year and an annual equivalent, at five percent interest. All figures are shown in thousands of Ethiopian dollars.

Benefit-Cost Analysis

Annual benefits from the Finchaa Project, under full development conditions, are Eth$25,336,000. Annual equivalent costs are Eth$7,373,000, assuming a fifty-year period of analysis and a five percent rate of interest.

On this basis, the ratio of benefits to cost for the Finchaa Project is:

$$\frac{\text{Eth\$}25{,}336{,}000}{\text{Eth\$ }7{,}373{,}000} = 3.44 \text{ to } 1.00$$

The following cost allocation discussion allocates the joint costs, in order to determine separate benefit-cost ratios for irrigation and power.

TABLE VIII-1 - SUMMARY OF COSTS AND ANNUAL COST EQUIVALENTS
FINCHAA PROJECT (ETH$1,000)

Feature	Construction cost	Interest during Construction	Capital costs	Annual		
				Interest and Amortization	OM&R	Total
		Irrigation				
Diversion dam	545	68	613			
East Main Canal	3,031	379	3,410			
West Main Canal	1,989	249	2,238			
Distribution and drainage system	10,547	1,318	11,865			
Land development	5,325	-	5,325			
Subtotal, irrigation	21,437	2,014	23,451	1,285	540	1,825
		Power				
Diversion dam	210	21	231			
Powerplant	11,015	1,102	12,117			
Power tunnel	32,948	3,295	36,243			
Transmission lines, etc.	21,004	2,100	23,104			
Subtotal, power	65,177	6,518	71,695	3,927	1,224	5,151
		Joint facilities				
Finchaa Dam and Reservoir	682	68	750			
Access roads	1,812	181	1,993			
Permanent camp	2,344	235	2,579			
Subtotal, Joint facilities	4,838	484	5,322	291	106	397
Total	91,452	9,016	100,468	5,503	1,870	7,373

28

Cost Allocation. There are two separate functions of the multiple-purpose Finchaa Project--irrigation and power. Some physical facilities are constructed specifically to serve irrigation, others specifically to serve power. Several, including the Finchaa Dam, the access road, and the permanent camp, are joint facilities constructed to serve both functions. The total costs of irrigation and power, therefore, are the cost of the facilities constructed specifically for that function, plus a portion of the costs of the joint facilities.

The Alternative Justifiable Expenditure method of cost allocation allocates costs of multiple-purpose projects according to a maximum allocation, a minimum allocation, and a sharing of joint costs. The maximum allocation, called the justifiable expenditure, is the highest cost that can be assigned to a function. This figure is the lesser of either the benefits expected to arise from construction and operation of the project, or of the costs of obtaining the same amount of benefit from the most likely alternative built in the absence of the project. The minimum allocation is the lowest cost which can be assigned to a function. It is the specific cost, or the cost which would be incurred only for irrigation or only for power. Specific costs include such facilities as the irrigation diversion dam, the powerplant, or the power tunnel. The joint costs are for facilities which are constructed to serve both functions, such as the Finchaa Dam or the access roads.

The allocation for irrigation or power is less than the maximum allocation but greater than the minimum allocation. It consists of the specific costs for each function, plus a sharing of the joint costs.

For the Finchaa Project, the costs of building the most likely alternative for both irrigation and power are less than the expected benefits which will arise from construction and operation of the project. The alternative costs, therefore, are the justifiable expenditure. The specific costs of irrigation are subtracted from the justifiable expenditure of irrigation; the same is done for power. The remainders are called the remaining justifiable expenditure. They are added together, and divided proportionally between irrigation and power.

Joint costs are then allocated to irrigation and power by these percentages, and added to the specific costs of each function. Therefore, total allocated costs of irrigation and of power are the sum of the specific costs of each function, plus a share of the joint costs.

Table VIII-2 lists specific and joint costs of the Finchaa Project, and Table VIII-3 allocates costs according to the Alternative Justifiable Method.

TABLE VIII-2 - SPECIFIC AND JOINT COSTS OF THE FINCHAA PROJECT
(Eth$1,000)

Item	Construction	Interest during Construction	Annual OM&R	Present worth OM&R	Total
Specific costs					
Irrigation	21,437 1/	2,014 2/	(540)	9,858	33,309
Power	65,177	6,518	(1,224) 3/	22,345	94,040
Joint costs	4,838	484	(106)	1,935	7,257
Total	91,452	9,016	(1,870)	34,138	134,606

1/Construction Eth$16,112
Development 5,325
21,437

2/Interest during construction is not applied on development costs.

3/Operation, maintenance, and replacement Eth$1,126
Taxes and insurance 98
1,224

289

TABLE VIII-3 - ALLOCATION OF COSTS OF THE FINCHAA PROJECT, BY USE OF THE ALTERNATIVE JUSTIFIABLE METHOD (ETH$1,000)

Item	Irrigation	Power	Total
Costs to be allocated			134,606
1. Annual benefits	8,936	16,400	25,336
Benefits capitalized	163,135	299,397	462,532
2. Alternative costs	37,742	99,326	137,068
Construction	24,322 1/	68,672	92,994
Interest during construction 2/	2,375	6,867	9,242
OM&R	11,045	23,787	34,832
(Annual OM&R)	(605)	(1,303)	(1,908)
3. Justifiable expenditure	37,742	99,326	137,068
4. Specific costs	33,309	94,040	127,349
Construction	21,437 1/	65,177	86,614
Interest during construction 2/	2,014	6,518	8,532
OM&R	9,858	22,345	32,203
(Annual OM&R)	(540)	(1,224)	(1,764)
5. Remaining justifiable expenditure	4,433	5,286	9,719
6. Percentage distribution	45.6	54.4	100.0
7. Allocated joint costs	3,309	3,948	7,257
Construction	2,206	2,632	4,838
Interest during construction	221	263	484
OM&R	882	1,053	1,935
(Annual OM&R)	(48)	(58)	(106)
8. Total allocated costs	36,618	97,988	134,606
Construction	23,643	67,809	91,452
Interest during construction	2,235	6,781	9,016
OM&R	10,740	23,398	34,138
(Annual OM&R)	(588)	(1,282)	(1,870)

1/Includes land development costs of Eth$5,325
2/No interest during construction is charged on land development costs.

290

Benefit-Cost Analysis, Irrigation. Annual irrigation benefits are Eth$8,936,000 and total costs allocated to irrigation are Eth$36,618,000. Table VIII-4 reduces irrigation costs to an annual equivalent basis, and indicates that annual costs chargeable to irrigation are Eth$2,006,000.

TABLE VIII-4 - SUMMARY OF IRRIGATION COSTS, FINCHAA PROJECT (ETH$1,000)

Feature	Construction	Interest during Construction	Capital costs	Annual		
				Interest and Amortization	OM&R	Total
East Main Canal	3,031	379	3,410			
West Main Canal	1,989	249	2,238			
Distribution and drainage system	10,547	1,318	11,865			
Service facilities	1,895	190	2,085			
Subtotal, canal system	17,462	2,136	19,598	1,074	577	1,651
Finchaa Dam and Reservoir	311	31	342		10	
Irrigation diversion dam	545	68	613		1	
Subtotal, diversion and storage system	856	99	955	52	11	63
Land development	5,325	-	5,325	292	-	292
Total	23,643	2,235	25,878	1,418	588	2,006

On this basis, the ratio of benefits to costs for irrigation is:

$$\frac{\text{Eth\$8,936,000}}{\text{Eth\$2,006,000}} = 4.45 \text{ to } 1.00$$

Benefit-Cost Analysis, Power. Annual power benefits are Eth$16,400,000 and total costs allocated to power are Eth$97,988,000 Table VIII-5 reduces power costs to an annual equivalent basis, and indicates that annual costs chargeable to power are Eth$5,367,000.

TABLE VIII-5 - SUMMARY OF POWER COSTS, FINCHAA PROJECT (Eth$1,000)

Feature	Construction	Interest during Construction	Capital costs	Annual		
				Interest and Amortization	OM&R	Total
Power diversion dam	210	21	231			
Powerplant	11,015	1,102	12,117			
Power tunnel	32,948	3,295	36,243			
Subtotal, power generation	44,173	4,418	48,591	2,662	704	3,366
Transmission plant	21,004	2,100	23,104			
Service facilities	2,261	226	2,487			
Subtotal, transmission and service facilities	23,265	2,326	25,591	1,401	565	1,966
Finchaa Dam and Reservoir	371	37	408	22	13	35
Total	67,809	6,781	74,590	4,085	1,282	5,367

On this basis, the ratio of benefits to costs for power is:

$$\frac{\text{Eth\$16,400,000}}{\text{Eth\$ 5,367,000}} = 3.06 \text{ to } 1.00$$

AMARTI-NESHE PROJECT

Benefits

Irrigation. Annual irrigation benefits of the Amarti-Neshe Project are expected to be Eth$5,062,000 under full development conditions. The gross crop income method of analysis shows that the Amarti-Neshe Project has an expected post-project income of Eth$595.70 per hectare. There is no pre-project income, so the increased income arising from project development is the same Eth$595.70 per hectare. Applied to the full project, gross crop income is approximately Eth$5,062,000 annually.

This gross income, or gross annual benefit arising from irrigation, will produce a similar reaction on the Ethiopian economy as the irrigation benefit from the Finchaa Project. However, the extent of the reaction will be less, since the gross benefit is smaller for the Amarti-Neshe Project.

Power. The same general statements made for the Finchaa Project apply here. The direct power benefit was arrived at in the same manner--i.e., using the alternative cost principle based upon a steam electric powerplant located near Addis Ababa. (See SECTION VII.) Direct power benefits by this method are estimated at Eth$17,110,000 annually.

The indirect and intangible power benefits to which no monetary value has been assigned are as outlined for the Finchaa Project.

Costs

Construction. Construction costs for the proposed multiple-purpose Amarti-Neshe Project, excluding land development costs, are Eth$123,020,000. These include Eth$9,487,000 for the irrigation facilities, Eth$56,274,000 for the power facilities, and Eth$57,259,000 for the joint-use facilities. Land development costs of Eth$3,014,000 bring total construction and development costs to Eth$126,034,000. Construction costs are amortized over a fifty-year period at five percent interest.

Interest during Construction. Interest during the construction period for the Amarti-Neshe Project is Eth$12,539,175 (Eth$12,539,000). This includes Eth$1,185,875 for irrigation, Eth$5,627,400 for power, and Eth$5,725,900 for the joint-use facilities. Interest during construction is amortized over a fifty-year period at five percent interest.

Development Costs. The Amarti-Neshe Project lies in the tropical savannah classification of lowland Ethiopian forest, and the vegetative growth on the project area is of sufficient thickness to classify the clearing costs as "heavy". Clearing costs are expected to approximate Eth$230 per hectare, or Eth$1,952,700 for the entire 8,490-hectare project.

The Amarti-Neshe Project area is gentle to rolling and falls into the "moderate" category of leveling. This category carries a charge of Eth$125 per hectare, or Eth$1,061,250.

Total clearing and leveling charges, collectively called development costs, are Eth$3,013,950 (Eth$3,014,000). Annual charges, determined by using the five-percent, fifty-year period factor, are Eth$165,000.

Operation, Maintenance, and Replacement Costs. Personnel costs required to operate and maintain the distribution and storage system of the 8,490-hectare Amarti-Neshe Project should be Eth$173,000 yearly. Costs for equipment, supplies, and general expenses will be approximately Eth$178,000 annually, for a total of Eth$351,000. In addition, Eth$31,000 will be required annually for operation, maintenance, and replacement of the portion of the joint-use facilities allocated to irrigation. Total costs then would be Eth$382,000 per year.

Other Costs. The same type of additional costs expected in the Finchaa area will apply to the Amarti-Neshe area. The costs of combating diseases, settling people in this new area, and social and

technical services will be substantial for this area, as they will be for the Finchaa. However, there will be no need to construct a road from Gedo, since this will be done for the Finchaa Project. Furthermore, unit costs of other factors may be cheaper, due to experience gained when developing the Finchaa.

Annual Cost Equivalents. To determine the ratio of benefits to costs of the multiple-purpose Amarti-Neshe Project, the annual equivalent costs are compared to annual benefits. Table VIII-6 summarizes the costs on a fifty-year and on an annual equivalent basis, at five percent interest.

TABLE VIII-6 - SUMMARY OF COSTS AND ANNUAL COST EQUIVALENTS--
AMARTI-NESHE PROJECT (ETH$1,000)

Feature	Construction costs	Interest during construction	Capital Costs	Annual		
				Interest and amortization	OM&R	Total
Irrigation						
Diversion dam	280	35	315			
South Main Canal	1,994	249	2,243			
North Main Canal	979	123	1,102			
Distribution and Drainage System	6,234	779	7,013			
Land Development	3,014	-	3,014			
Subtotal, irrigation	12,501	1,186	13,687	750	351	1,101
Power						
Powerplant	37,247	3,725	40,972			
Power tunnel	2,251	225	2,476			
Power canal	2,213	221	2,434			
Transmission lines, etc.	14,563	1,456	16,019			
Subtotal, power	56,274	5,627	61,901	3,391	1,244	4,635
Joint Facilities						
Amarti dam and reservoir	12,267	1,227	13,494			
Neshe dam and reservoir	39,867	3,987	43,854			
Access roads	2,938	294	3,232			
Permanent camp	2,187	218	2,405			
Subtotal, joint facilities	57,259	5,726	62,985	3,450	129	3,579
Total	126,034	12,539	138,573	7,591	1,724	9,315

Benefit-Cost Analysis

Annual benefits from the Amarti-Neshe Project under full development conditions are Eth$22,172,000. Annual equivalent costs are Eth$9,315,000, assuming a fifty-year period of analysis and a five-percent rate of interest. On this basis, the ratio of benefits to costs for the Amarti-Neshe Project is:

$$\frac{\text{Eth\$22,172,000}}{\text{Eth\$ 9,315,000}} = 2.38 \text{ to } 1.00$$

The following cost allocation discussion allocates the joint costs, in order to arrive at separate benefit-cost ratios for irrigation and for power.

Cost Allocation. The Alternate Justifiable Expenditure method of cost allocation is used to allocate joint costs of the Amarti-Neshe Project between irrigation and power. Table VIII-7 lists the specific and joint costs of the project, and Table VIII-8 allocates costs according to this method.

TABLE VIII-7 - SPECIFIC AND JOINT COSTS OF THE AMARTI-NESHE PROJECT (ETH$1,000)

Item	Construction	Interest during Construction	Annual OM&R	Present Worth, OM&R	Total
Specific Costs					
Irrigation	12,501 1/	1,186 2/	(351)	6,408	20,095
Power	56,274	5,627	(1,244) 3/	22,710	84,611
Joint Costs	57,259	5,726	(129)	2,355	65,340
Total	126,034	12,539	(1,724)	31,473	170,046

1/ Construction $9,487
Development 3,014
12,501

2/ Interest during construction is not applied on development costs

3/ Operation, maintenance, and replacement $1,160
Taxes and insurance 84
1,244

TABLE VIII-8 - ALLOCATION OF COSTS OF THE AMARTI-NESHE PROJECT BY USE OF THE ALTERNATIVE JUSTIFIABLE METHOD (ETH$1,000)

Item	Irrigation	Power	Total
Costs to be allocated			170,046
1. Annual benefits	5,062	17,110	22,172
Benefits capitalized	92,411	312,359	404,770
2. Alternative costs	40,592	148,225	188,817
Construction	29,276 1/	112,345	141,621
Interest during construction 2/	3,283	11,235	14,518
OM&R	8,033	24,645	32,678
(Annual OM&R)	(440)	(1,350)	(1,790)
3. Justifiable expenditure	40,592	148,225	188,817
4. Specific costs	20,095	81,611	104,706
Construction	12,501 1/	56,274	68,775
Interest during construction 2/	1,186	5,627	6,813
OM&R	6,408	22,710	29,118
(Annual OM&R)	(351)	(1,244)	(1,595)
5. Remaining justifiable expenditure	20,497	63,614	84,111
6. Percentage distribution	24.4	75.6	100.00
7. Allocated joint costs	15,943	49,397	65,340
Construction	13,971	43,288	57,259
Interest during construction	1,397	4,329	5,726
OM&R	575	1,780	2,355
(Annual OM&R)	(31)	(98)	(129)
8. Total allocated costs	36,038	134,008	170,046
Construction	26,472	99,562	126,034
Interest during construction	2,583	9,956	12,539
OM&R	6,983	24,490	31,473
(Annual OM&R)	(382)	(1,342)	(1,724)

1/ Includes land development costs of $3,014.
2/ No interest during construction is charged on land development costs.

Benefit-Cost Analysis, Irrigation. Annual irrigation benefits are Eth$5,062,000, and total costs allocated to irrigation are Eth$36,038,000. Table VIII-9 reduces irrigation costs to an annual equivalent basis and indicates that total annual costs chargeable to irrigation are Eth$1,974,000.

TABLE VIII-9 - SUMMARY OF IRRIGATION COSTS--
AMARTI-NESHE PROJECT (ETH$1,000)

Feature	Construction costs	Interest during construction	Capital Costs	Annual		
				Interest and amortization	OM&R	Total
South Main Canal	1,994	249	2,243			
North Main Canal	979	123	1,102			
Distribution and Drainage System	6,234	779	7,013			
Service Facilities	1,250	125	1,375			
Subtotal, Canal System	10,457	1,276	11,733	643	375	1,018
Amarti Dam and Reservoir	2,993	299	3,292			
Neshe Dam and Reservoir	9,728	973	10,701			
Irrigation Diversion Dam	280	35	315			
Subtotal, Diversion and Storage System	13,001	1,307	14,308	784	7	791
Land Development	3,014	-	3,014	165	-	165
Total	26,472	2,583	29,055	1,592	382	1,974

On this basis, the ratio of benefits to costs for irrigation is:

$$\frac{\text{Eth\$5,062,000}}{\text{Eth\$1,974,000}} = 2.56 \text{ to } 1.00$$

298

Benefit-Cost Analysis, Power. Annual power benefits are Eth$17,110,000 and total costs allocated to power are Eth$134,008,000. Table VIII-10 reduces power costs to an annual equivalent basis, and indicates that annual costs chargeable to power are Eth$7,341,000.

TABLE VIII-10 - SUMMARY OF POWER COSTS--AMARTI-NESHE PROJECT, (ETH$1,000)

Feature	Construction costs	Interest during construction	Capital Costs	Annual		
				Interest and amortization	OM&R	Total
Power canal	2,213	221	2,434			
Powerplant	37,247	3,725	40,972			
Power tunnel	2,251	225	2,476			
Subtotal, power generation	41,711	4,171	45,882	2,513	731	3,244
Transmission plant	14,563	1,456	16,019			
Service facilities	3,875	388	4,263			
Subtotal, transmission and service facilities	18,438	1,844	20,282	1,111	590	1,701
Amarti Dam and Reservoir	9,274	927	10,201			
Neshe Dam and Reservoir	30,139	3,014	33,153			
Subtotal, storage system	39,413	3,941	43,354	2,375	21	2,396
Total	99,562	9,956	109,518	5,999	1,342	7,341

On this basis, the ratio of benefits to costs is:

$$\frac{\text{Eth\$17,110,000}}{\text{Eth\$ 7,341,000}} = 2.33 \text{ to } 1.00$$

SECTION IX - ADMINISTRATION AND OPERATION

Governmental and Administrative Organization

Administrative organizations responsible for the development of natural resources vary between nations, depending upon the objectives, laws, governmental policies, and availability of skills and financial supports. Responsibilities are frequently divided among several agencies. The need for a central organization to establish and apply uniform treatment to all sectors of development and to coordinate the multiple uses and demands upon resources is recognized.

Resource development, however, is so complex that its effects may reach to every unit of governmental organization, and all agencies of government will share an interest, some to a greater extent than others. Therefore, the agency that must administer the program should be so constituted as to recognize and consider the requirements and the responsibilities of other agencies of government.

Initially, the Water Resources Department, an established agency under the direction of the Ministry of Public Works and Communication, could become the agency to administer the program. It could probably better serve the needs of the Nation if it were an autonomous agency operating under the broad direction of a board consisting of representatives from the ministries and agencies of the Government sharing major interest in this field. The primary purposes of the Water Resources Department or any succeeding agency should be to conserve and safeguard the land and water resources, promote orderly economic development of these resources, protect existing rights, provide for equitable distribution and allocation of water between the various uses, and guide the development of projects to the greatest beneficial use for the enjoyment of the people of the Nation.

Since the role to be played by the Water Resources Department in the development of land and water resources projects has not as yet been clearly defined and since no determination has been made regarding the methods of financing projects or repaying of the costs of construction, it would seem desirable for the Imperial Ethiopian

Government initially to appoint an expert committee on resource development. The committee should consist of representatives of the various ministries and agencies, including represention from the Water Resources Department, supported by experienced consultants if required. It would review and study existing legislation and customs relating to the utilization of land and water resources and the responsibilities of the various governmental agencies in this field. This committee should recommend legislation as required to provide the authority for a centralized agency for the development of the Nation's land and water resources through the construction, operation, and maintenance of hydroelectric, irrigation, and related projects.

The committee should recommend:

1. A charter for the centralized agency, setting forth the objectives, authority, and responsibility.

2. A water code insuring adequate control and regulation of the use of water for power, agriculture, industry, and municipal and domestic supply.

3. A plan to consolidate and/or coordinate the activities of the various agencies now operating in this field.

4. A plan for financing the costs of projects and retirement of obligations.

The development of the basic organizational principles would then support the gradual development of an organizational structure for the agency and for specific projects similar to that discussed and illustrated in subsequent paragraphs.

Consideration should be given to the possible advantages of consolidating or merging existing agencies whose functions may overlap as the program for resource development gains momentum. The Surveys and Mapping Division of the Water Resources Department and the Mapping and Geography Institute might well be consolidated into one Geodetic Survey and Mapping Agency. The Ethiopian Electric Light and Power Authority and the Water Resources Department have a common purpose, except that the Water Resources Department must consider multiple-purpose projects. The two could be consolidated under a common board of directors with the former becoming the Power Division of the new organization. The existing Water Resources Department organization could become the Engineering, Irrigation, and Development Divisions, and the Administrative Divisions of the two agencies could combine under the new central organization. These consolidations would reduce the cost of administration; recognize the value of an existing, well trained, and successfully operating power

unit; and provide for more efficient management as the organization grows to meet the expanding needs of multiple-purpose projects.

Agricultural Operations

National Goals

The ultimate goal of agricultural development in Ethiopia is the more efficient use of the natural resources of the Nation to bring about greater production of agricultural products, improve the national economy, and create additional employment opportunities for the national labor force. At the same time, such development should also establish a system which will permit the emergence of a class of farmers who can successfully own and operate commercial farms and make independent managerial and cultural decisions. Such farmers would hold title to their lands, enjoy the benefits of a higher standard of living, and have a voice in the conduct of affairs of their community.

This goal, which appears to be most advantageous both to the farmer and to the Nation in higher production of agricultural goods and in a stable land owning class of independent farmers, is not one that can be attained easily or quickly. A proper framework of legislation providing for land ownership and tenure and for an equitable system of taxation and other reforms is necessary. Equally important is the development of the aptitudes and abilities, as well as the incentive and ambition, of the individual farmer.

Few farmers under the existing situation have the ability to operate a modern irrigated farm successfully without considerable assistance and guidance. The Ethiopian farmer of today is a subsistence producer, using antiquated tools and implements and raising those crops which will meet the immediate needs of his family. Storage facilities are poor; machinery and commercial fertilizers are unavailable; and the lack of roads and other transport facilities generally limits the area of marketing to the production area. The average Ethiopian family has an income of Eth$170 to Eth$300 per year.1/ This income, to which the rural Ethiopian has become accustomed, provides the bare necessities of life. Under these conditions, the farmer contributes only a small amount to the national economy, compared to his potential contribution if agricultural efforts were more efficiently organized.

Farm Family Income Objective

A stronger economy can be created if the farmer can acquire sufficient land and productive facilities to provide an adequate

1/Sample surveys made by Water Resources Department personnel in Shewa, Wellegga, and Gojjam Provinces in 1960 and 1961.

30

standard of living. The farmer's income level should enable him to pay for his farm over a period of years, provide adequate housing, educate his children, and put aside in savings an amount sufficient to meet emergencies and provide the necessities in later life when he is no longer able to perform productive labor.

Annual farm income must be increased to meet these objectives. Studies of potential production from farms under an irrigation development in the Finchaa valley indicate that, under full development, an average farm size would be 17 hectares (42 acres). Thus the Finchaa Project with an ultimate size of 15,000 hectares would be divided into 880 farm units. This number of units would provide farming opportunities for 880 families directly and, when laborers and their families are included, agricultural livelihood for about 65,000 people. It would also create off-farm employment opportunities for at least that many more.

The 17-hectare size would be sufficient to provide an adequate standard of living for the farm family, pay farm expenses, and provide a contingency factor for emergencies, capital savings, and a small fund for future taxation. This is based upon the land utilization pattern, crop prices, and yields outlined in Tables VI-4 and VI-7, SECTION VI. The improved level of living includes a better house, a more plentiful and varied diet, and proper medical and educational facilities. Estimates of income requirements to achieve these family living allowances are of a reconnaissance nature, based largely on surveys taken in Ethiopia in recent years, and are shown in Table IX-1.

TABLE IX-1 - CASH REQUIREMENT PER FAMILY

Item	Amount per year (Eth$)
Housing	30
Food	470
Beverages	151
Clothing	222
Utilities	226
Education	100
Health, religion, and entertainment	57
Sundries	106
Total	1,362

The Eth$1,362, plus the contingency, capital savings, and taxation factors, would be provided by the average 17-hectare farm unit.

Development Period

Since it is recognized that today there are few Ethiopian farmers who have the financial resources and the experience and knowledge of modern irrigated farming to permit them to assume full responsibility for immediately successful management and operation of project farms, a development period must be allowed. During this period, the farmers would require financial assistance in the form of long-term, low-interest loans; intensive technical assistance in agricultural practices; guidance in farm layout and operation and direction of field labor; and initially, some degree of management of their over-all operation. Also during this development period, the responsibilities for management and operation would gradually be shifted to the farmers as they demonstrate ability to initiate and execute appropriate managerial and operational decisions.

The physical characteristics of the Finchaa Project are such that the irrigation development can proceed by stages over a period of years. The initial stage on the Finchaa should include about 20 farms with development to be accelerated yearly, assuming satisfactory results, until the project is in full operation. With effective management, adequate technical guidance and assistance, acceptance of responsibility, and emergence of initiative on the part of the farmer, a 10- to 15-year development period may be adequate.

Settler Selection and Assistance

The selection of farmers, particularly in the early period, is of vital importance to the success of the project. Farmers should be willing to learn the procedures of modern farming or should have the educational background which would qualify them technically. They must be cooperative and willing workers. The College of Agriculture and the agricultural schools at Jima and Ambo should be excellent sources of candidates.

During the development period, the necessary clearing, land leveling, and farm unit layout should be scheduled to assure the proper expansion of cultivated land. A staff of technical experts provided by the Extension Service of the Ministry of Agriculture and other agencies, to guide and assist farmers during this period, should include the following:

Agronomist
Marketing Specialist
Field Operations Coordinator
Irrigation Engineer
Farm Equipment Specialist
Health and Sanitation Advisor
Education Advisor
Home Economist

Training Farm

In addition to the privately operated farms, a training farm approach offers possibilities for successful development. A number of eventual farm units could be combined and initially operated by the Manager of Agriculture (discussed in a subsequent paragraph) and his assistants. Ethiopian farmers would be employed in a temporary category of hired potential farmers. As they acquire competence and demonstrate a willingness to own and operate farm units, portions of this training farm area could be released from central management and placed under private control.

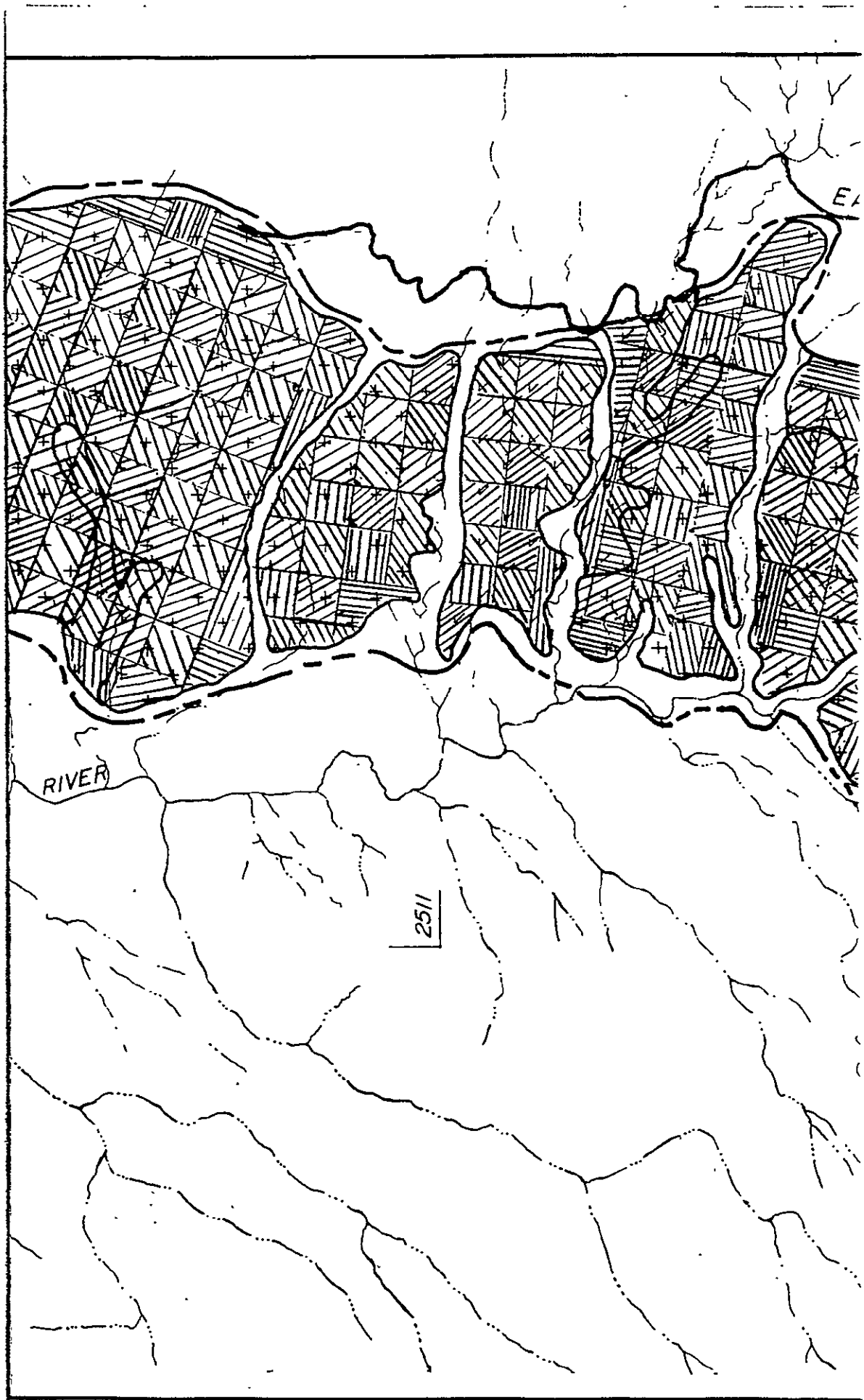
In this process, the selection of farmers is less critical because poor candidates could be removed in the early stages of operation before they were placed on private farms. Failure of a hired farmer would be less expensive in terms of time, financial support, extension service backing, and social capital than the failure of an independent farmer.

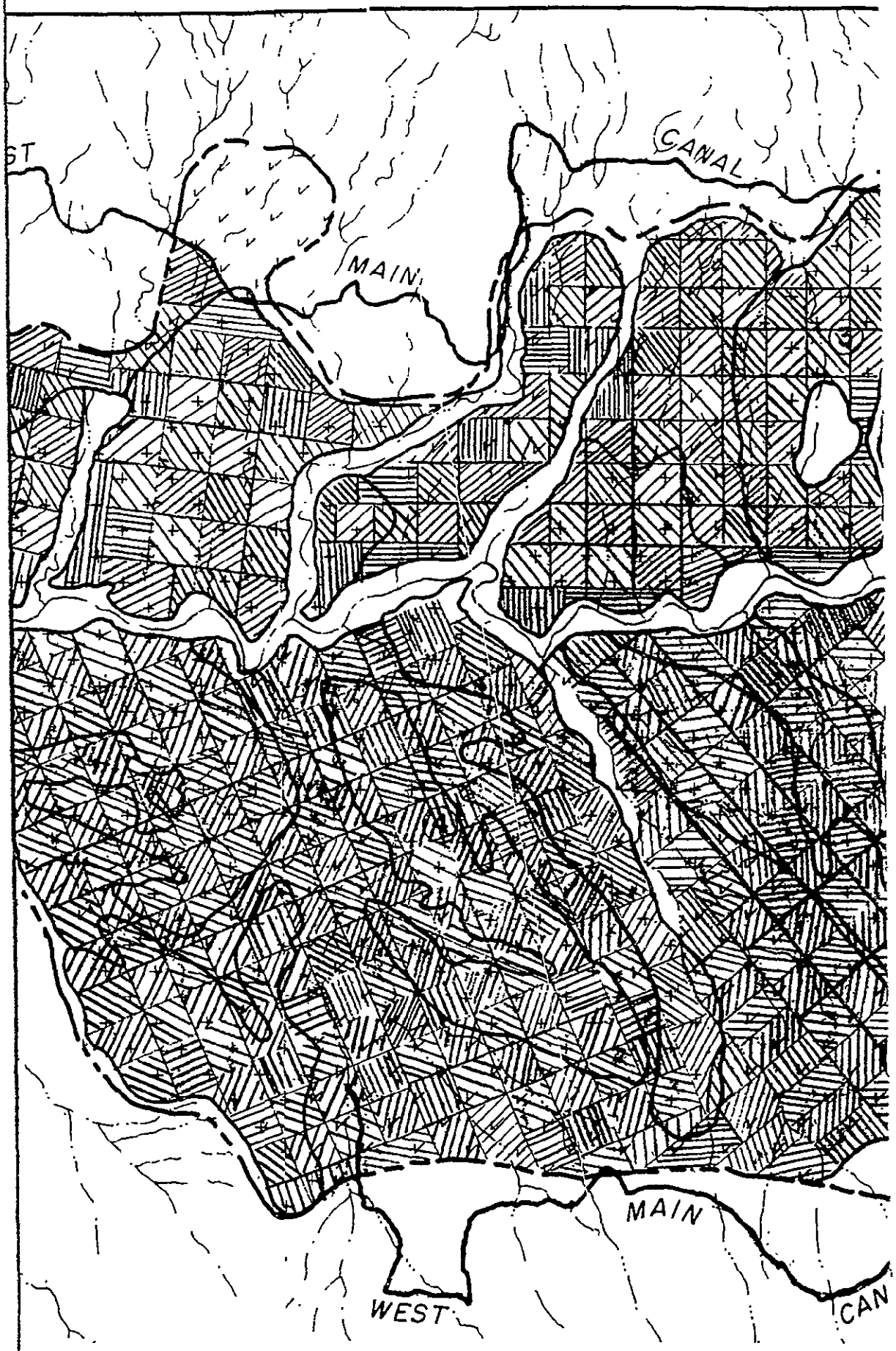
A training farm of approximately 340 hectares should be operated in this manner. This is equal in area to 20 independent farms. An operation of this magnitude would increase farm production, augment the number of men qualified to enter independent farming, and provide a gage to measure the relative success of the independent operations.

Drawing No. 7.2-Fi-1 shows the preliminary farm layout of the Finchaa Project.

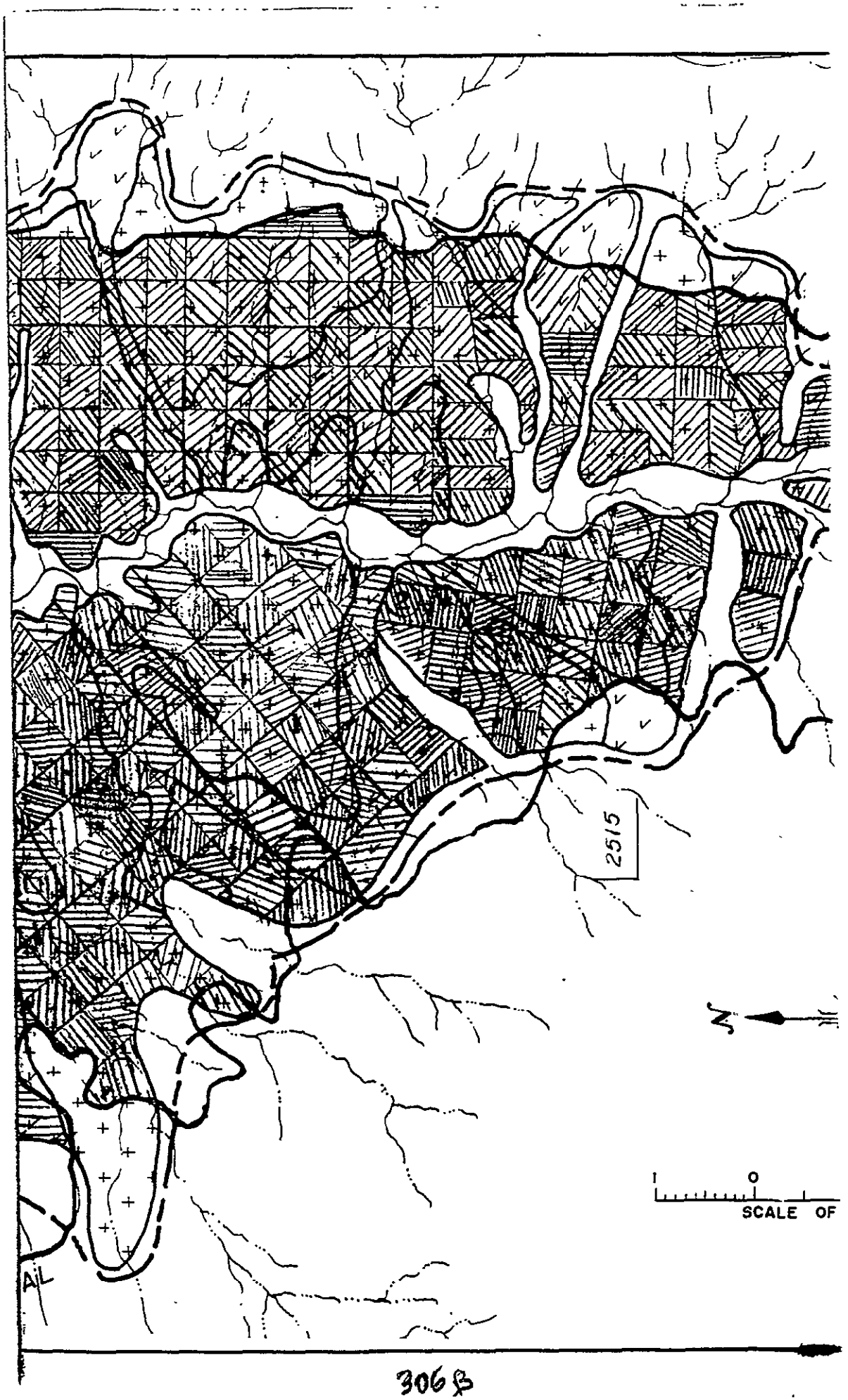
Experimental Farm

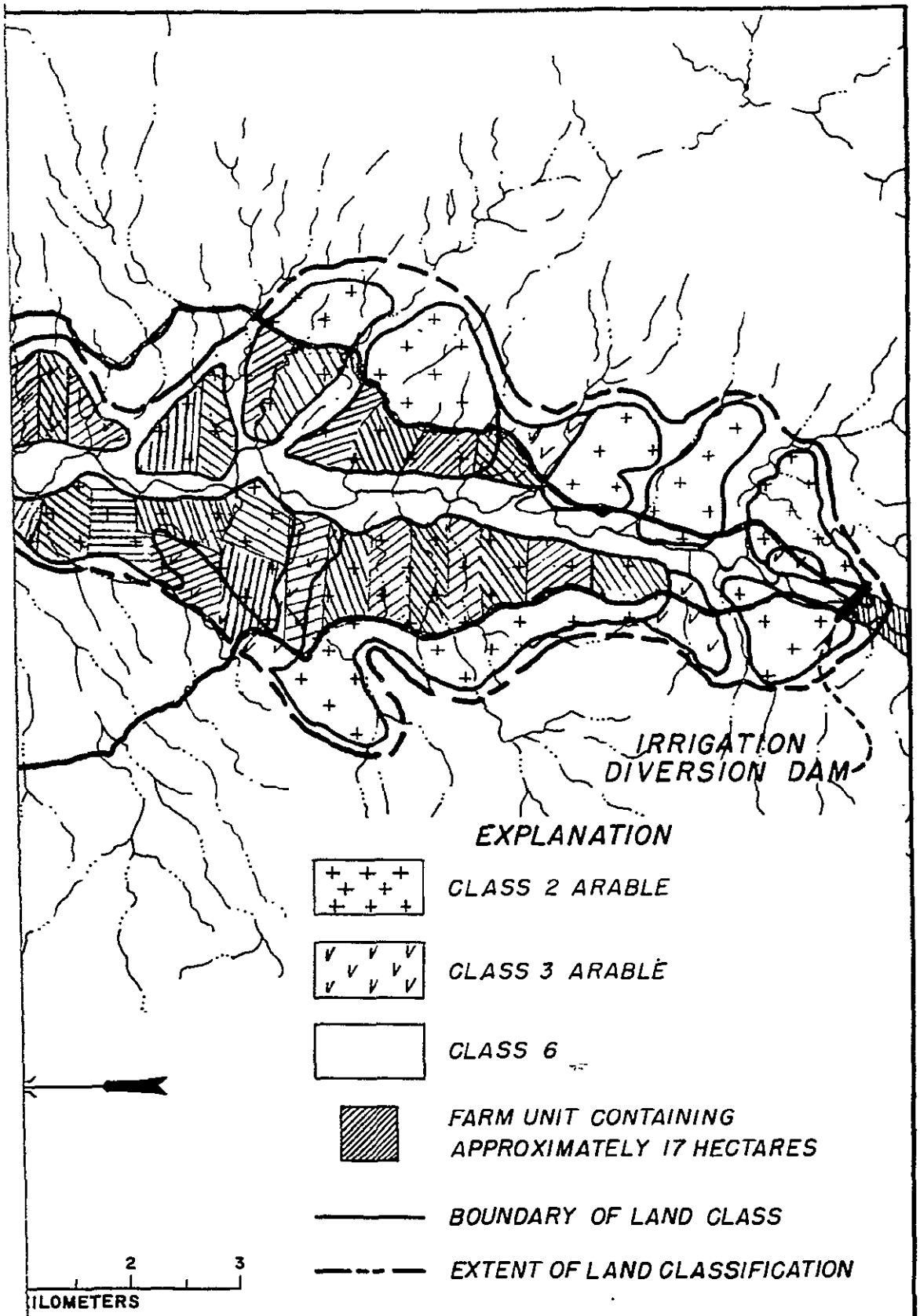
The immediate establishment of a small experimental farm of several hectares in the Finchaa Project to test crops, cultural practices, machinery use, fertilizer and lime requirements, and insect, disease, and weed control is necessary. Such a unit should have permanent status and should constantly test new crops, varieties, and practices as well as provide a continuous check upon the older selections. Initially, this unit should confine its recommendations to crops selected in the cropping pattern but should, in the course


RIVER
2511



306A


2515
N
1
0
SCALE OF
AiL



BLUE NILE RIVER BASIN

FINCHAA RIVER PROJECT

PRELIMINARY FARM LAYOUT

NOVEMBER 8, 1963

7.2-Fi-1

300 C

of time, test the "exotic" or introduced crops which may become important in the future. An agronomist who is responsible to the Manager of Agriculture should direct this operation.

Manager of Agriculture

The Manager of Agriculture should supervise all Finchaa Project field operations. He must be well acquainted with all phases of commercial agriculture and modern irrigation and should possess proven ability to direct and encourage personnel. Ideally, he should be recruited from a successful irrigated plantation or farm with a good record of accomplishment and production. The salary paid should be sufficient to attract well-qualified personnel and should be supplemented by a share of profits for greater incentive. Since there are few large-scale irrigated farms in Ethiopia, it is possible that the first Finchaa Project Manager of Agriculture may be a foreign national. Later his position can be filled by an Ethiopian with the required technical background and well qualified by training on the job. Years of irrigation and commercial crop production and a knowledge of the myriad diverse factors producing successful operation are required on the part of such a manager if the project is to be successful.

The Manager of Agriculture should exercise full control over the training farm and a certain degree of regulation, decreasing with time, over the independent farmers. He should have the permanent functions of operating the experimental farm, developing the raw land, and operating and maintaining the irrigation storage and distribution system.

This manager with his staff of assistants should receive advisory service from the Agricultural Development Commission (discussed in a subsequent paragraph). He also requires staff assistance from technical specialists who are expert in various fields of agriculture, health, and education. These positions should concentrate their efforts upon the farmers but should not neglect the workers on the training farm, especially those nearing the stage of independent operations.

All personnel who perform direct service to the project, whether in the form of guidance, technical direction, operation of the distribution facilities, or management, should live at the project. This point is essential to avoid absentee direction. Absentee ownership of farms is also to be avoided. It is entirely possible that certain farmers may become successful enough to place their lands under a foreman and live in the city, but this should not be permitted. Every effort is necessary to demonstrate to the

farmers that this is their project and not the property of absentee owners residing in the capital or elsewhere.

Agricultural Development Commission

The concept of commercial irrigated farming is relatively new in Ethiopia, and consequently few farmers have had opportunity to gain experience in the field of modern agriculture. Partially to offset this situation, it is thought advisable to utilize the services of an Agricultural Development Commission at the project level, which would serve in an advisory capacity as the irrigation projects came into operation. A single commission should be created for the Finchaa Project and should be expanded to include responsibility for other projects as they develop in the immediate vicinity.

Ideally, the appointments for the Agricultural Development Commission should be made from agencies interested in resource development who could offer technical advice when so requested. The Ministry of Agriculture, the Ministry of National Community Development, the Ministry of Public Health, and the College of Agriculture could provide much needed technical support. Each commission should include representation from the project in the presence of at least one farmer familiar with local problems who can suggest solutions from the viewpoint of the project residents.

Future Studies

In any future study of the Finchaa Project the proposals which concern management should be further considered. The qualifications, duties, and salaries of the Manager of Agriculture, the technical experts, and the service personnel should be established. The appointment of members of the Agricultural Development Commission and their terms of office should be considered. And the processes for the selection of project farmers should be formulated. The overall personnel factor, of vital importance to project operations, should be studied thoroughly and recommendations made after careful consideration. Many other facets, which are only briefly mentioned in this section, should also receive careful attention.

Electric Power Operations

Central Organization

The present Ethiopian Electric Light and Power Authority is a well established and operated organization, and its charter states:

"The purpose of the Authority is to engage in the business of producing, transmitting, distributing and selling electrical energy to the public in Ethiopia and to carry on any other lawful business incidental or appropriate hereto which is calculated directly or indirectly to promote the interest of the Authority to enhance the value of its properties." 1/

Paragraph 4 of the same charter also states:

"..... the Authority shall have the powers: (f) to establish rates, charges, rules and regulations for the sale of its services and electrical energy." 1/

The charter thus implies that EELPA is a major agency in producing, transmitting, and marketing electrical energy in Ethiopia (excluding existing concession areas in Eritrea), and therefore any discussion of the future role that the Water Resources Department or any succeeding agency may have in this field would have to recognze this already established fact. A developing country cannot initially afford two separate governmental organizations competitively engaged in the public utility business, requiring some duplication of engineers, other specialists, and resultant costs, where such qualified personnel are in very short supply.

Phase I Operations. The present EELPA organization chart is shown by Drawing No. 4.0-BN-175. While the desirable objective may be in having only one autonomous governmental agency involved in the power generation, transmission, and marketing field, this can still be accomplished by EELPA and the Water Resources Department operating under the Phase I arrangement as shown by Drawing No. 4.0-BN-176. Phase I operations are also adaptable to any private power utility, should such come into existence in the future.

Under Phase I, EELPA becomes in effect the Power Division and is directly responsible for power operations, maintenance, and marketing. A common Board of Directors for both Water Resources and EELPA will provide for proper coordination where multiple-purpose projects are involved, but considerable responsibility is placed in the hands of the Board of Directors. The Assistant Manager (Power) for Multiple-Purpose Projects provides the necessary direct liaison between the managerial levels of the two agencies. Also, it is through this level that power planning activities of both agencies are coordinated. If EELPA assumes the operation, maintenance, and marketing responsibilities, then it should participate in the power planning activities.

1/General Notice No. 213 of 1956, Charter.

Enacting laws as recommended by the Government Committee could establish the concept of multiple-purpose projects requiring that a part of power revenues returned to the Federal Treasury be used in financing or retiring indebtedness incurred in the construction of multiple-purpose projects. At the same time, a reasonable return must be allowed the power operating agency. Establishing the details of such arrangements is beyond the scope of those reconnaissance investigations requiring average rate and repayment studies which in turn require considerably more detail and information than currently available.

The present charter for EELPA specifies the following item regarding taxation.

> "9. Taxation--The Authority shall be subject to all taxes and custom duties levied by the Imperial Ethiopian Government including Federal Taxes, and such local and municipal taxes as shall be approved by the Imperial Ethiopian Government." 1/

If the taxation obligation remains in its present form, then this will have a definite effect upon the rate of return required for any power operating agency from operation of the power facilities of multiple-purpose projects. The over-all effect will be to require higher rates than would otherwise be necessary. A reduction in tax obligations only on power generated from government-owned, water resource, multiple-purpose projects resulting in lower cost power may provide an added inducement for EELPA to participate as a partner under Phase I operations.

While it is possible for Phase I operations to continue indefinitely, a final step resulting in complete consolidation of the two agencies would be most desirable to afford greater economy and efficiency as has been the result in a number of other developing countries.

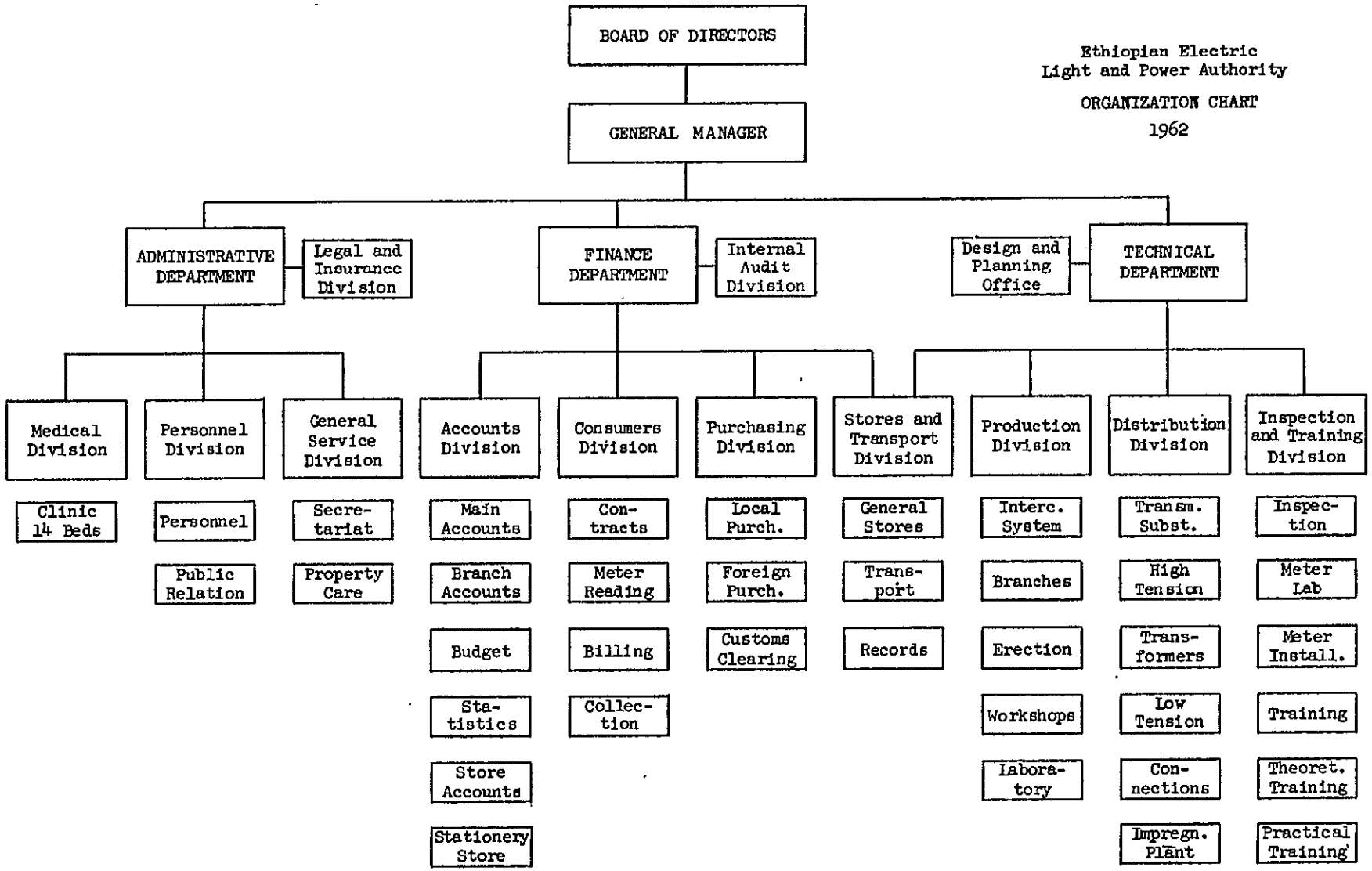
Phase II Operations. Under Phase II, both agencies would be combined as one autonomous agency. For convenience, it is referred to here as the Ethiopian Power and Water Resources Agency (EP&WRA), and in effect the former EELPA becomes the Power Division of the new agency and the Water Resources Department becomes the Engineering, Irrigation, and Development Divisions with the Administrative Division made up from the combined agencies. The new EP&WRA would be under a Board of Directors as shown on Drawing No. 4.0-BN-177, but administered by a General Manager. The Power Division would have four branches--Marketing, Planning, Operation and Maintenance, and Dispatching. The functions of each branch would be as described below.

1/General Notice No. 213 of 1956, Charter.

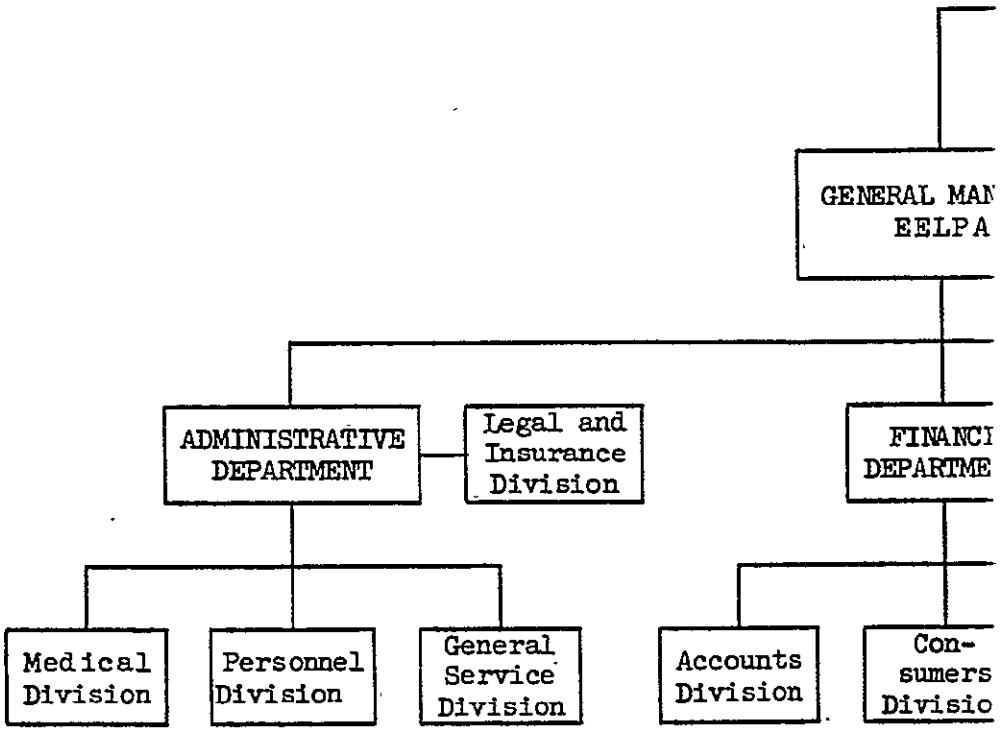
34

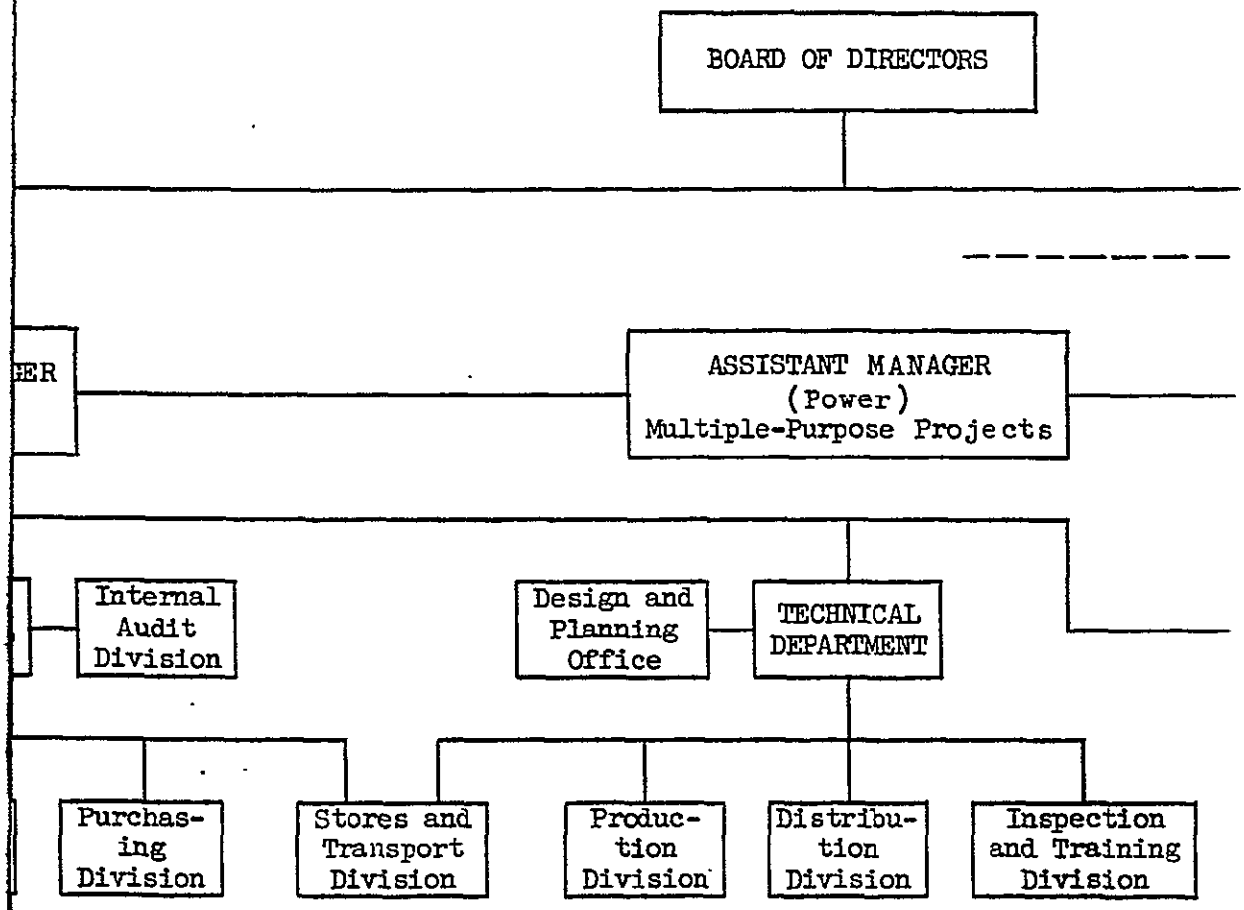
Ethiopian Electric
Light and Power Authority

ORGANIZATION CHART
1962

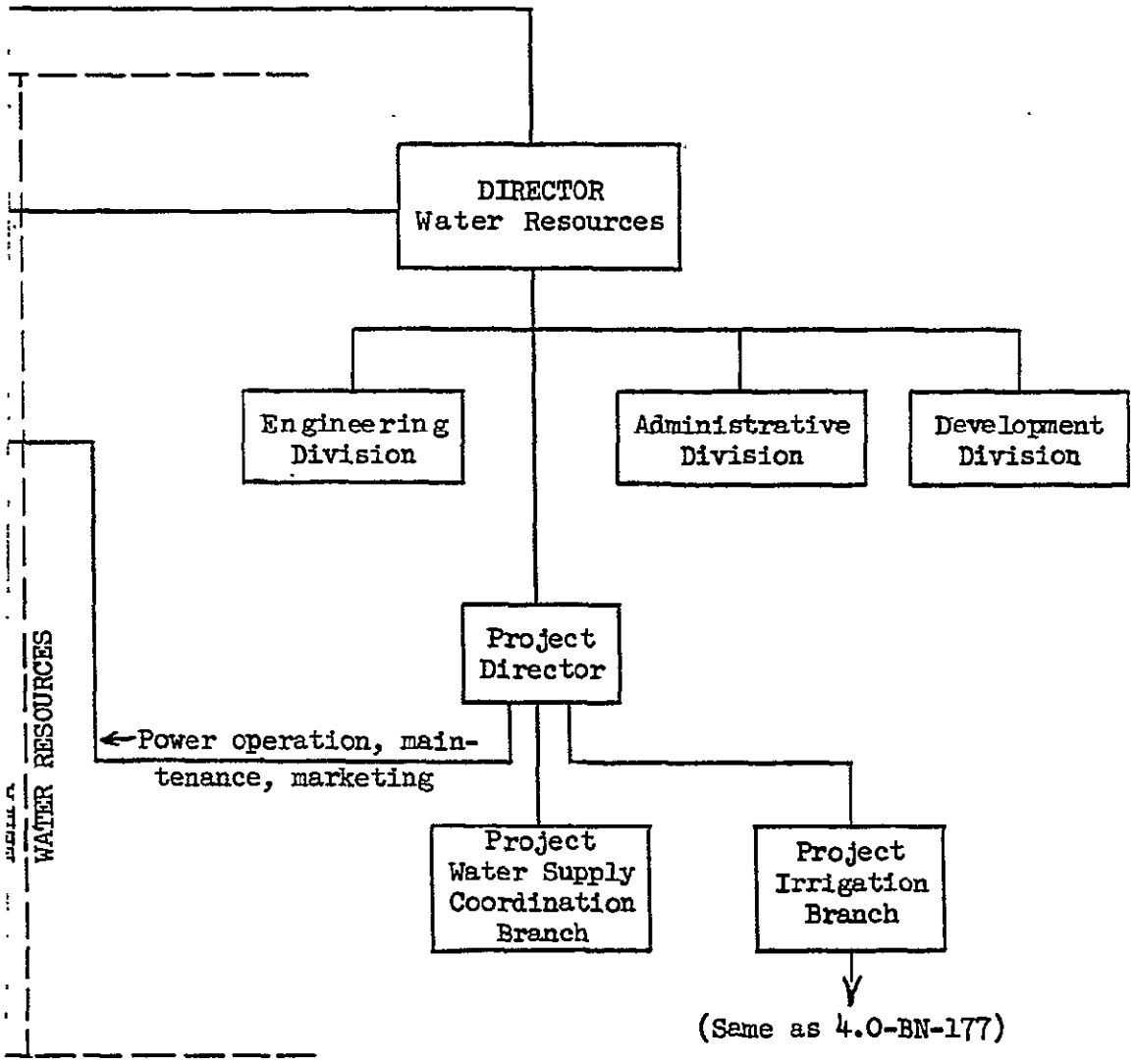


4.0-BN-175

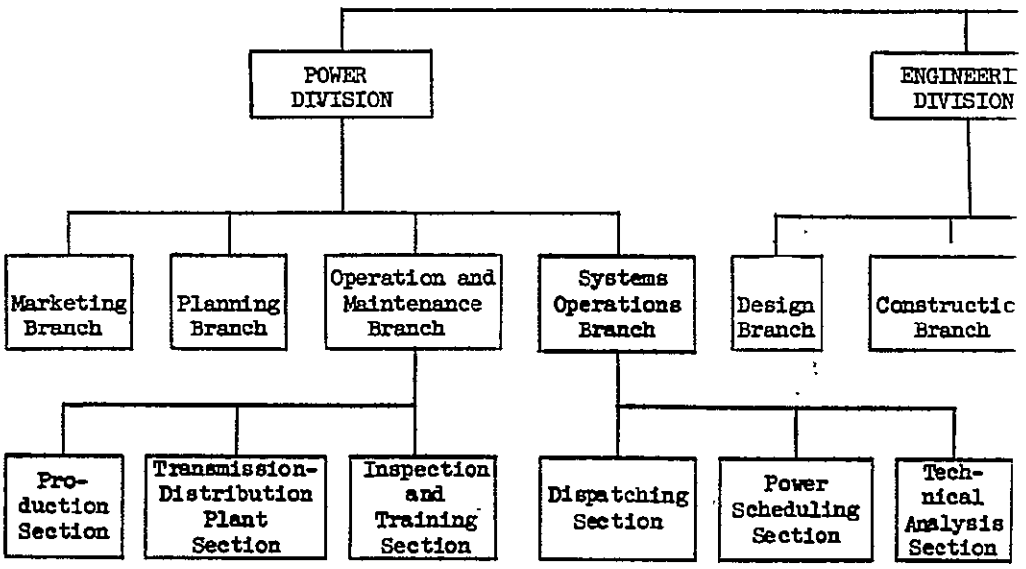

GENERAL MAN
EELPA
ADMINISTRATIVE DEPARTMENT
Legal and Insurance Division
FINANCI
DEPARTME
Medical Division
Personnel Division
General Service Division
Accounts Division
Con-
sumers
Divisio

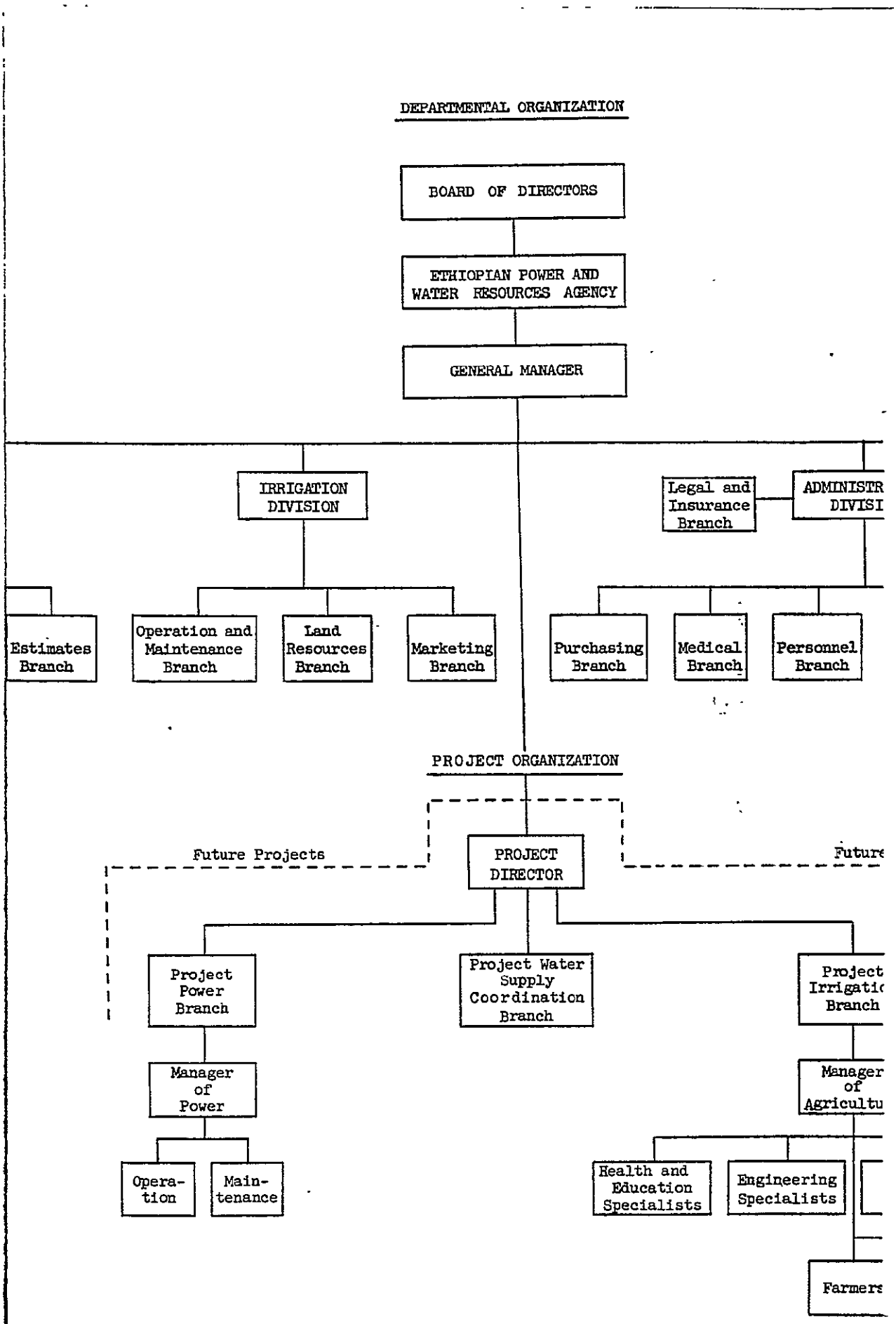

BOARD OF DIRECTORS
HER
ASSISTANT MANAGER
(Power)
Multiple-Purpose Projects
Internal Audit Division
Design and Planning Office
TECHNICAL DEPARTMENT
Purchas-ing Division
Stores and Transport Division
Produc-tion Division
Distribu-tion Division
Inspection and Training Division

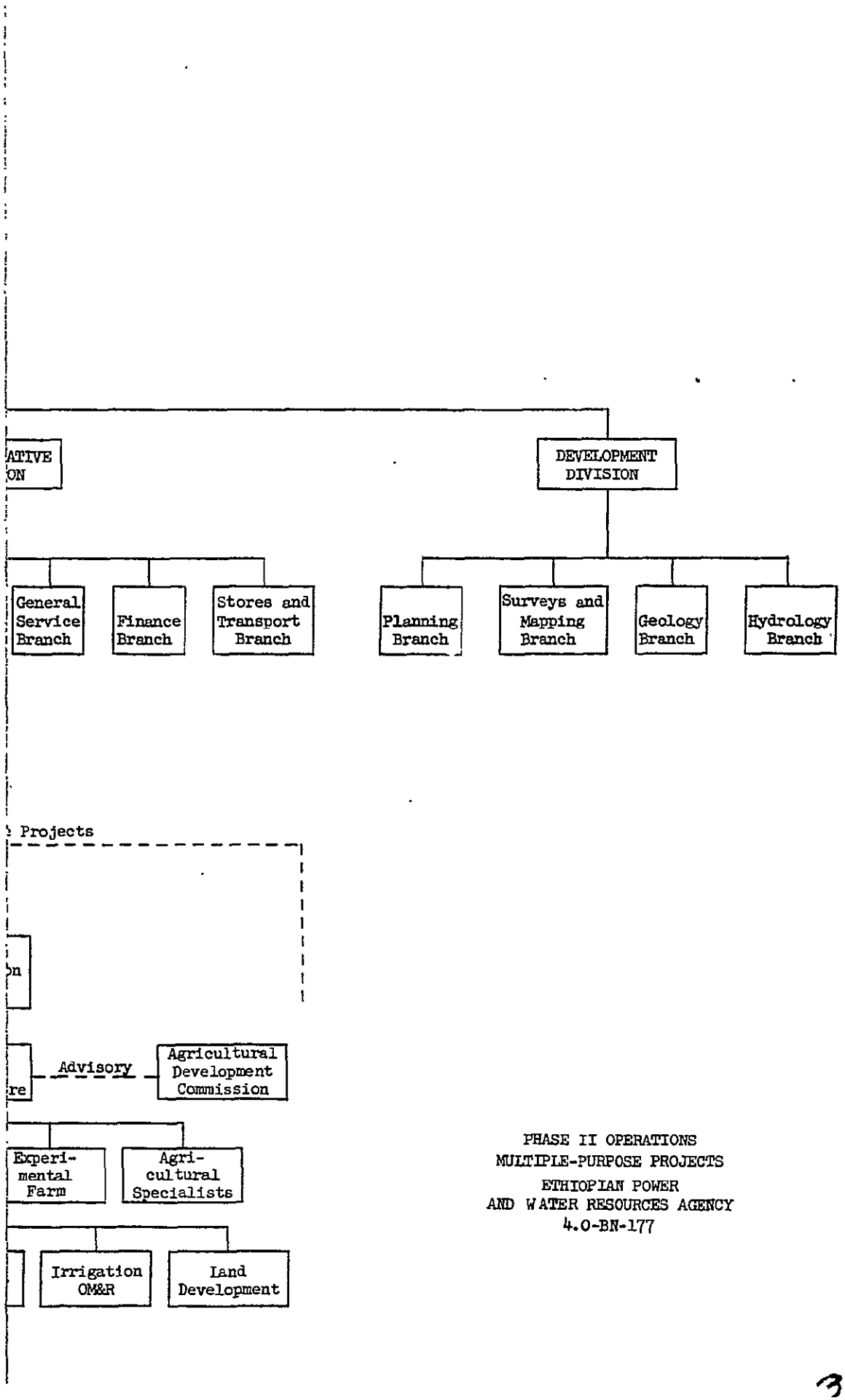
312A



PHASE I OPERATIONS
MULTIPLE-PURPOSE PROJECTS
EELPA AND WATER RESOURCES DEPARTMENT
4.0-BN-176

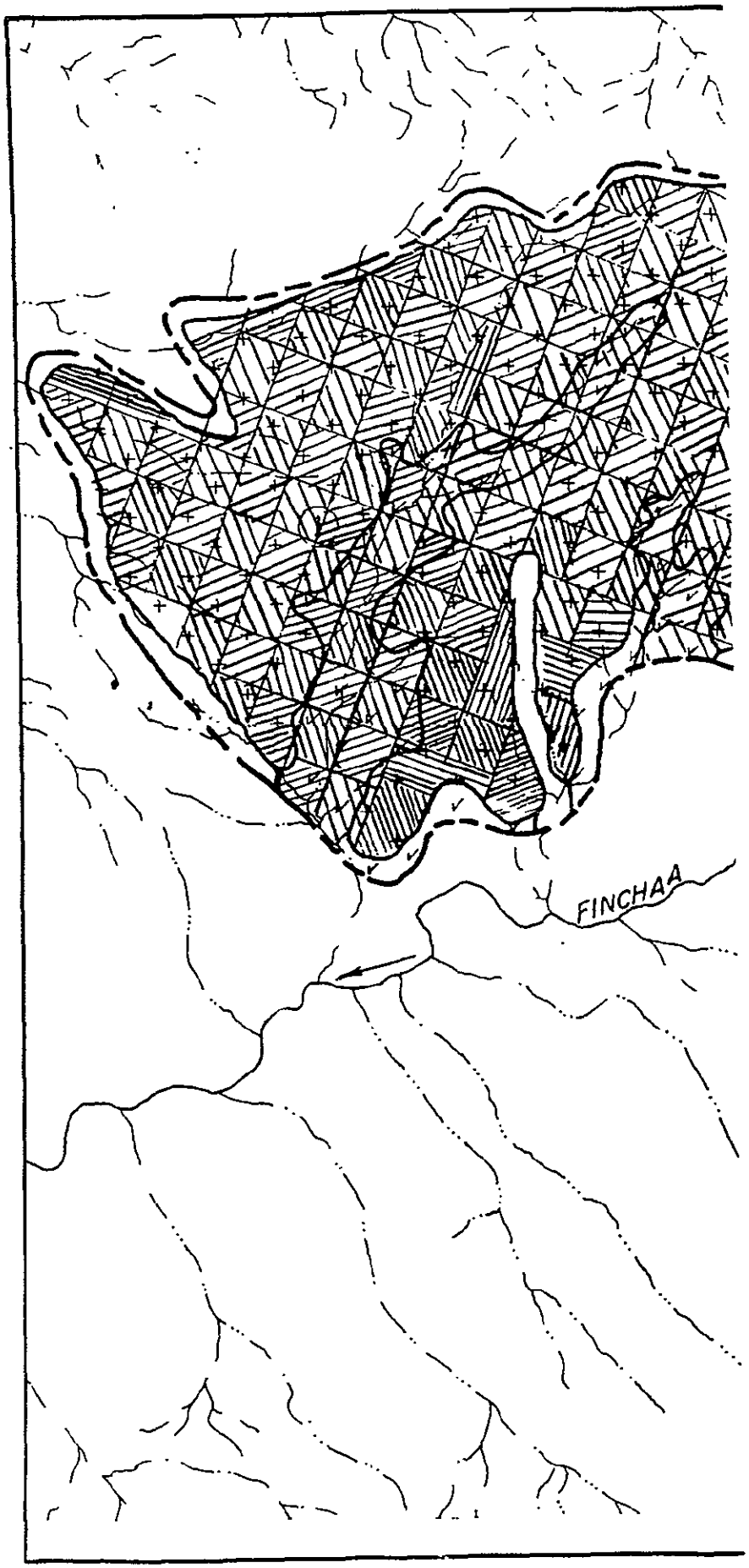

POWER DIVISION
ENGINEERI DIVISION
Marketing Branch
Planning Branch
Operation and Maintenance Branch
Systems Operations Branch
Design Branch
Constructic Branch
Pro-duction Section
Transmission-Distribution Plant Section
Inspection and Training Section
Dispatching Section
Power Scheduling Section
Tech-nical Analysis Section


DEPARTMENTAL ORGANIZATION
BOARD OF DIRECTORS
ETHIOPIAN POWER AND WATER RESOURCES AGENCY
GENERAL MANAGER
IRRIGATION DIVISION
Legal and Insurance Branch
ADMINISTR DIVISI
Estimates Branch
Operation and Maintenance Branch
Land Resources Branch
Marketing Branch
Purchasing Branch
Medical Branch
Personnel Branch
PROJECT ORGANIZATION
Future Projects
PROJECT DIRECTOR
Future
Project Power Branch
Project Water Supply Coordination Branch
Project Irrigati Branch
Manager of Power
Manager of Agricultu
Opera-tion
Main-tenance
Health and Education Specialists
Engineering Specialists
Farmers



PHASE II OPERATIONS
MULTIPLE-PURPOSE PROJECTS
ETHIOPIAN POWER
AND WATER RESOURCES AGENCY
4.0-BN-177

313.B


FINCHAA

Marketing: This branch would be responsible for negotiating power sales contracts, reading meters, billing, and collection. It would also gather statistics and have available at all times a breakdown of sales by classes of loads--residential, rural, commerce, industry, street and highway lighting, transportation, and other. Such data would be available for use by the Planning Branch.

Planning: Load forecasting, feasibility studies for system additions, rate and repayment studies for the power aspects of multiple-purpose development, and technical power studies are among the duties of this branch.

Operation and Maintenance: This branch might have three sections--Production, Transmission-Distribution Plant, and Inspection and Training. On multiple-purpose projects, technical guidance (operation and maintenance) would be given the Project Power Branch, but the latter is administratively under the Project Director for the project. The Transmission-Distribution Plant Section would be responsible for maintenance of all transmission and distribution lines as well as substations and related equipment. It would also operate the wood-pole treating plants. In order to maintain an adequate supply of trained personnel, the Inspection and Training Section could teach linemen, powerplant operators, meter installers, laboratory technicians (transformer oil breakdown tests, meter testing, etc.), electricians, and inspectors. The latter would be for inspection of customers' premises as well as the agency's own facilities. This section would also be responsible for maintaining an adequate electrical wiring code and enforcing its provisions as well as providing maintenance for all communication facilities.

System Operations: This branch might also have three sections--Dispatching, Power Scheduling, and Technical Analysis. Initially, this branch's activities would be limited because of the simple nature of the system, but it would become more active as more generating stations and loads are added. In any event, its activities would be limited to the Interconnected System. The Dispatching Section would be responsible for meeting load requirements and schedules as well as for controlling all switching and clearances. The Power Scheduling Section would be responsible for developing system-wide scheduling on a day-to-day basis, consistent with scheduled water releases. The Technical Analysis Section would be responsible for system operation at maximum efficiency. Emergency switching programs and studies regarding system control (relays, etc.) would be the responsibility of this section.

Close liaison between the System Operations Branch and the Hydrology Branch under the Development Division would be required regarding reservoir operations. All reservoir operation studies

forecasting reservoir releases for appropriate advance periods should be made by Reservoir Operations, Hydro ogy Branch, under the Development Division. This information would be given to the System Operations Branch, Power Division as well as to each individual Project Director where multiple-purpose projects are in operation. The Project Director, through his Projects Water Supply Coordination Branch (Drawing No. 4.0-BN-177), would be finally responsible for implementing instructions received from Reservoir Operations. Drawing No. 4.0-BN-177 shows the Project Director and staff arrangement for a multiple-purpose project. For single-purpose power projects only, there would be no irrigation and therefore the Projects Water Supply Coordination Branch would not be concerned. Reservoir Operations supply the data to System Operations and to the Project Director.

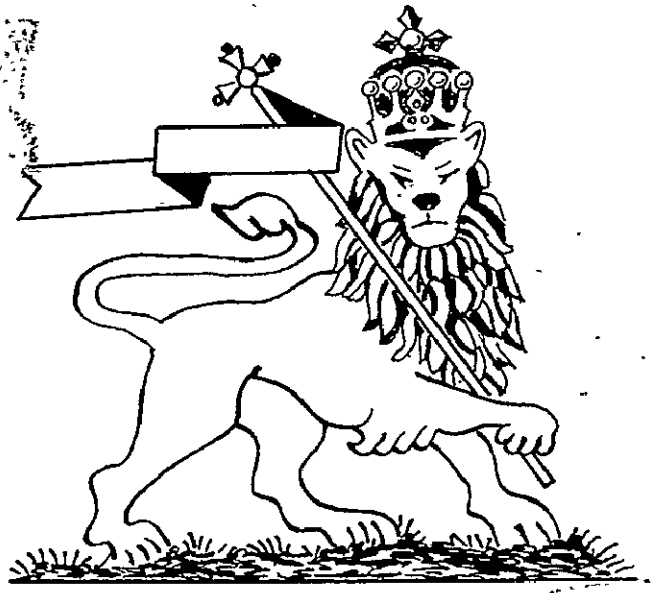
Project Power Operations

Each project or convenient combination of projects, such as the Finchaa and the Amarti-Neshe, would be headed by a Project Director. Under the director is the Projects Power Branch, consisting of a power Manager heading two sections, an Operation Section and a Maintenance Section. These two operate the powerplants, taking hourly instructions from the Dispatching Branch, Central Office, and maintain the powerplant and appurtenant works. The function of the Projects Water Supply Coordination Branch has already been discussed.

For single-purpose power projects, the Power Director would have only two groups under him, one Operation and the other Maintenance, with the same responsibilities as before except that activities would not be restricted to the powerplant and appurtenances but would apply to all features of the project, including the storage facilities.

PN-ABP-832
84293

Land and Water Resources of the BLUE NILE BASIN



ETHIOPIA

FINCHAA RIVER SUB-BASIN

A.I.D.
Reference Center
Room 1656 NS

Prepared for the Department of State
Agency for International Development

By the United States Department of the Interior
Bureau of Reclamation

1963

LAND AND WATER RESOURCES OF THE BLUE NILE BASIN

ETHIOPIA

FINCHAA RIVER SUB-BASIN

United States
Department of the Interior

Bureau of Reclamation

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
WASHINGTON 25, D. C.

IN REPLY REFER TO: 220

JAN 6 1964

Mr. Stephen Christmas
Officer-in-Charge
Horn of Africa
Department of State
Agency for International Development
Washington, D. C. 20523

Dear Mr. Christmas:

In accordance with your request of October 4, 1963, we have prepared an advance reconnaissance report for the Finchaa Project in the Blue Nile River Basin in Ethiopia. It will be noted that the report also contains information on the Amarti-Neshe Project in the same river basin.

During the early stages of the Blue Nile investigation program, the Finchaa and the Amarti-Neshe were considered as one project with the water supply for the project lands coming from the Finchaa River. Project data, particularly geology and land classification, were prepared on the basis of a single project. Later it was found that the water supply from the Finchaa River was not adequate to irrigate all of the project lands and that the Amarti and Neshe Rivers offered good possibilities for the development of hydroelectric power. The plan was then separated into the two projects.

Since the ultimate development of the Finchaa River Basin will include both projects and since the data are interrelated, it appeared advisable to report on both projects. The projects will also be covered in the forthcoming Blue Nile Report.

The reconnaissance investigation and evaluation of the Finchaa Project at this stage indicate its economic feasibility. However, further detailed surveys and analysis are necessary before a final determination of feasibility can be made.

For the purpose of the economic evaluation of the irrigation project, we have used farms averaging about 17 hectares (40 acres) in size. This is consistent with our understanding that the objectives of the Imperial Ethiopian Government are to improve

the national economy and raise the standard of living of the Ethiopian people. The 17-hectare farm would support these improvements, while smaller farms would tend to perpetuate the present subsistence operation.

During the past few years, the IEG has developed several projects --Wonji sugar, Koka powerplant, Zula dam, Tendaho, and others --somewhat independently, with only limited, if any, coordination. For initial development, this is not serious. However, as the development is accelerated and the demands upon Ethiopian resources increase, this lack of coordination could have serious effects. Therefore, it is recommended that the IEG give consideration to the establishment of a central agency to administer and coordinate the long-range development program.

From an engineering standpoint, the Finchaa Project appears to be feasible.

The economic success of the Finchaa Project is dependent upon the Ethiopian people, who must plan and direct the development, and upon those who will operate the facilities and the farms. If they accept this responsibility with a sincere desire for success and if they apply their talents with vigor and enthusiasm, it can be a successful venture. The resources are there. It is up to the Ethiopian people to develop and use them wisely.

Sincerely yours,

Commissioner

TRANSLITERATION

Certain inconsistencies in the spelling of names may be noted on maps and drawings and in the text. Because of the difficulty in transliterating Arabic, Amharic, Galla, and Italian into exact English equivalents, some variation of spellings and even in names occurs in the basic maps and drawings. It will be noted, however, that the phonetic pronunciation of names is similar regardless of spelling, except in the rare situation where an entirely different English name is used because of long established convention. An example of the latter is the name for the principal river, Blue Nile, which in Amharic is known as Abbay (Abbai). Addis Ababa is often referred to as Addis Abeba. Other examples are as follows:

Lekkemt	Nekemti
Acachi	Akaki
Jima	Jimma, Gima
Langano	Langana
Shashamane	Shashamana
Shewa	Shoa

In western and northwestern Ethiopia, local usage of Arabic words for streams and mountains is usually retained. For example, "Jebel" denotes mountain and "Khor" identifies a watercourse. In addition, the English name or abbreviation sometimes precedes the Arabic term, as with "Mt. Jebel Kir."

Local usage sometimes requires different names along different lengths of the same river. For example, the Guder River is known as Tacur, Bello, and Guder.

Wherever possible, a consistent spelling has been used for identical places in this report.

ABBREVIATIONS, CONVERSION FACTORS, AND ETHIOPIAN MONETARY AND CALENDAR EQUIVALENTS

Abbreviations:
- EELPA = Ethiopian Electric Light and Power Authority
- IEG = Imperial Ethiopian Government

Conversion Factors: Metric-English Systems
- 1 meter (m.) = 39.37 inches = 3.2808 feet
- 1 kilometer (km.) = 0.6214 mile = 3,280.8 feet
- 1 square meter (sq. m.) = 1.196 square yards = 10.764 square feet
- 1 hectare (ha.) = 10,000 square meters = 2.471 acres = 1/100 square kilometer
- 1 hectoliter = 0.1 cubic meter = 2.838 bushels; 26.417 gallons
- 1 square kilometer (sq. km.) = 0.3861 square mile = 100 hectares = 247.1 acres
- 1 cubic meter (cu. m. or m^3) = 1,000 liters = 1.308 cubic yards = 35.31 cubic feet
- 1 cubic meter = 0.000,810,7 acre-foot
- 1 acre-foot = 1,233 cubic meters
- 1 kilogram (kg.) = 2.204 pounds
- 1 kilogram per hectare (kg/ha) = 0.8926 pound per acre
- 1 metric ton = 2,204 pounds = weight of 1 cubic meter of water
- 1 kilogram per square centimeter (kg./sq. cm.) = 14.22 pounds per square inch = 32.8 feet of water
- 1 cubic meter per second ($m^3/s.$) = 35.31 cubic feet per second (c. f. s.)
- 1 English horsepower = 550 foot-pounds per second
- 1 metric horsepower = 75 kilogram-meters per second
- 1 metric horsepower = 0.9863 English horsepower = 735.45 watts
- 1 cubic meter of water per second under 1 meter head = 9.81 kilowatts at 100 percent efficiency
- 1 million cubic meters of water under 1 meter head = 2,730 kilowatt-hours at 100 percent efficiency

Temperature Conversion:

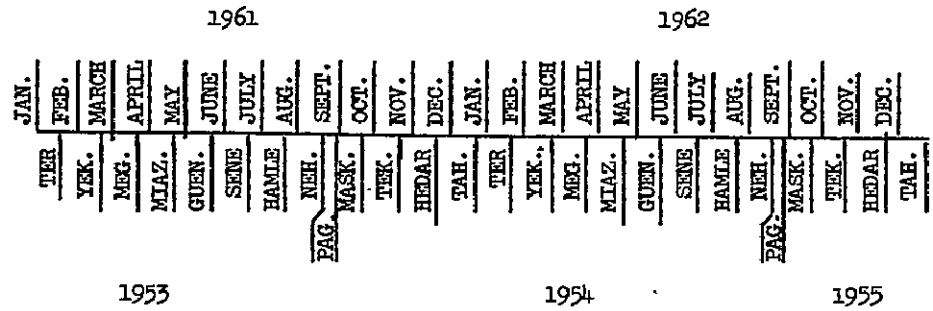
Centigrade: $C. = \frac{5}{9}(F^\circ - 32)$ Fahrenheit: $F. = \frac{9}{5}C^\circ + 32$

Ethiopian-United States Monetary Values: Rate of exchange used in this report
1 United States dollar (US$1.00) = 2.50 Ethiopian dollars (Eth$2.50)

Ethiopian Calendar (30-day months, except Pagumen):

Maskaram	= Sept. 11 - Oct. 10	Miazia	= April 9 - May 8
Tekemt	= Oct. 11 - Nov. 9	Guenbot	= May 9 - June 7
Hedar	= Nov. 10 - Dec. 9	Sene	= June 8 - July 7
Tahessas	= Dec. 10 - Jan. 8	Hamle	= July 8 - Aug. 6
Ter	= Jan. 9 - Feb. 7	Nehasse	= Aug. 7 - Sept. 5
Yekatit	= Feb. 8 - March 9	Pagumen	= Sept. 6 - Sept. 10
Megabit	= March 10 - April 8		

UNITED STATES OR GREGORIAN CALENDAR



ETHIOPIAN CALENDAR

CONTENTS

	Page
TRANSMITTAL LETTER	
TRANSLITERATION	i
CONVERSION FACTORS	ii
TABLE OF CONTENTS	iii
LIST OF TABLES	vii
LIST OF DRAWINGS	xiii
LIST OF PHOTOGRAPHS	xvii
SECTION I - INTRODUCTION	
Authority and Scope	1
Summary	5
Conclusions	9
Recommendations	10
SECTION II - GENERAL DESCRIPTION	
Basin Description	13
Projects Area Description	14
Population	14
Present Economy	14
Climate	15
Quality of Water	15
SECTION III - HYDROLOGY	
Finchaa Project	21
Operation Study	21
Estimate of Available Flow	22
Area-Capacity Relationships	22
Monthly Power Releases	23
Irrigated Area	23
Spillway Design Flood	23
Flood Frequency	23
Outlet Capacity	23

6

	Page
Amarti-Neshe Project	24
Operation Study	24
Estimate of Available Flow	24
Area-Capacity Relationships	24
Monthly Power Releases	24
Irrigated Area	39
Spillway Design Flood	39
Flood Frequency	39
Outlet Capacity	39
SECTION IV - GEOLOGY	
General Geology of the Area	43
Geologic Reconnaissance	44
Seismology	44
Ground Water	44
SECTION V - PLANS AND ESTIMATES	
Comprehensive Plan of Development	45
Finchaa Project	45
Plan of Development	45
Project Features	46
Finchaa Dam and Reservoir	46
Site Geology	47
Construction Materials	48
Access to Sites	49
Power Diversion Dam	49
Power Tunnel and Penstocks	49
Powerplant	50
Transmission Plant	51
Irrigation Diversion Dam	54
Main Canals	54
Distribution System and Drains	55
Service Facilities	56
Estimates of Construction Cost	56
Plan Selection and Alternatives	57
Amarti-Neshe Project	59
Plan of Development	59
Project Features	59
Amarti-Neshe Dams and Reservoirs	59
Site Geology	61
Construction Materials	62
Access to Sites	63
Power Canal	63
Power Tunnel and Penstocks	63
Powerplant	64

	Page
Transmission Plant	65
Irrigation Diversion Dam	66
Main Canals	66
Distribution System and Drains	67
Service Facilities	67
Estimates of Construction Cost	67
Plan Selection and Alternatives	68
SECTION VI - IRRIGATION DEVELOPMENT	
Finchaa Project	71
Introduction	71
General Description	71
Location and Extent	71
Physiography	72
Transportation and Habitation	72
Present and Potential Land Use	73
Project Lands	73
Topography and Land Development	73
Drainage	75
Soils	75
Land Classification	77
Agricultural Economics	81
Agricultural Conditions before Project Development	81
Agricultural Conditions after Project Development	81
Alternative Crops	89
Livestock	102
Land Settlement	102
Amarti-Neshe Project	103
SECTION VII - POWER	
Background	105
Factors in Power Market Analysis	105
Power Market Areas Studied	105
Physical Characteristics	106
Population	107
Occupations of Labor	108
Natural Resources	110
Principal Economic Activities	112
Income	129
Development of Electric Energy Use	131
National Economy	132
Mineral Products	143
Iron and Steel	145
Miscellaneous	146
Other (Transport and Communications)	146
Public Consumption and Illumination	149

8

	Page
Present Electric Rates	151
Cost of Electricity and Other Energy Sources	151
Past, Present, and Estimated Future Power Requirements	156
System Conditions Considered for this Study	157
Existing Power Systems	157
Past, Present, and Future Requirements	160
Energy and Demand at Load Centers	165
Summary	178
Estimated Future Need for Additional Generator Capacity--1964-1967	178
Power Facilities Planned or Under Consideration --1964-1967	181
Estimated Future Deficiency in Power Supply --1968-1980	182
Finchaa Sub-Basin as a Source in Meeting Future Deficiencies in Power Supply	182
Reserves	188
System Installation Schedule	188
Estimated Power Costs of Alternative Sources	189
Finchaa Hydroelectric Powerplant and Related Facilities	189
Neshe Hydroelectric Powerplant and Related Facilities	191
Summary	193
SECTION VIII - ECONOMIC ANALYSIS	
Finchaa Project	195
Benefits	195
Costs	200
Benefit-Cost Analysis	202
Amarti-Neshe Project	209
Benefits	209
Costs	209
Benefit-Cost Analysis	212
SECTION IX - ADMINISTRATION AND OPERATION	
Governmental and Administrative Organization	217
Agricultural Operations	219
National Goals	219
Farm Family Income Objective	219
Development Period	221
Settler Selection and Assistance	221
Training Farm	222
Experimental Farm	222
Manager of Agriculture	223
Agricultural Development Commission	224
Future Studies	224
Electric Power Operations	224
Central Organization	224
Project Power Operations	228

LIST OF TABLES

Number	Title	Page
II-1	Climatic Stations in or near Abbay Basin in Ethiopia	17
II-2	Temperature at Ambo Agricultural School in ° C. --Daily Minima	18
II-3	Temperature at Ambo Agricultural School in ° C. --Average Daily and Daily Maxima	19
II-4	Precipitation in mm. at Ambo Agricultural School	20
III-1	Reservoir Operation Study--Finchaa Reservoir	25
III-2	Computation of Finchaa Farm Delivery Requirement	28
III-3	Inflow Design Flood--Finchaa Damsite	29
III-4	Flood Frequency at Damsites--Finchaa and Amarti-Neshe Projects	30
III-5	Reservoir Operation Study--Neshe and Amarti Reservoirs	31
III-6	Area-Capacity Tables--Neshe and Amarti Reservoirs --showing 50- and 100-year Sediment Distribution	34
III-7	Maximum Probable Flood--Amarti and Neshe Combined	40
III-8	Maximum Probable Flood--Neshe (without Amarti)	41
V-1	Detailed Cost Estimates--Finchaa Project	follows 56
V-2	Estimated Construction Cost Summary--Finchaa Project	58
V-3	Detailed Cost Estimates--Amarti-Neshe Project	follows 68
V-4	Estimated Construction Cost Summary--Amarti-Neshe Project	69
VI-1	Subreconnaissance Land Classification Standards	79
VI-2	Arable and Irrigable Areas--Finchaa and Amarti-Neshe Projects	80

10

Number	Title	Page
VI-3	Wholesale Prices in Addis Ababa and in the Finchaa Area	87
VI-4	Summary of Farm Income for Estimating Benefits by Gross Crop Income Method--Finchaa Project--100-hectare Basis	follows 88
VI-5	Summary of Farm Income for Estimating Benefits by Gross Crop Income Method--Finchaa Project--15,000-hectare Basis	follows 88
VI-6	Production and Disposition of Crops, Expressed in Terms of Calories	90
VI-7	Summary of Farm Income for Estimating Benefits by Gross Crop Income Method--Amarti-Neshe Project--100-hectare Basis	follows 103
VI-8	Summary of Farm Income for Estimating Benefits by Gross Crop Income Method--Amarti-Neshe Project--8,490-hectare Basis	follows 103
VII-1	Estimated 1961 Population by Cities	107
VII-2	Population for Blue Nile River Basin by Provinces in the Basin--1961	107
VII-3	1961 Population Estimates--Ethiopia	108
VII-4	Estimated Age Structure in Ethiopia Compared with Data for Some Other Countries	109
VII-5	Land-Use Areas	111
VII-6	Gross Domestic Product Estimates over the 20-year Period	113
VII-7	Estimated Investment during a 20-year Period	114
VII-8	Forecast Trend in Export of Certain Agricultural Products	114
VII-9	Summary of Industry in the 13 Provinces (Year Ended Sept. 10, 1961)	116
VII-10	Index of Economic Trend of Industrial Production (1955 = 100)	117
VII-11	1967 Production Goal for Selected Industrial Products	118
VII-12	Investment in Manufacturing Industry by Years	119
VII-13	Number of Industrial Projects to be Constructed --1963-1967	119

Number	Title	Page
VII-14	Industrial Projects to be Put into Operation--1963-1967	119
VII-15	Forecast Trend in Exports by Sectors	122
VII-16	Forecast Trend in Export of Industrial Products	122
VII-17	Scheduled Mineral Production, by Years (1963-1967)	123
VII-18	Forecast Gross Value of Mineral Production	123
VII-19	Port Assab Traffic--1952-1960	126
VII-20	Planned Investments in the Period 1963-1967	128
VII-21	Employment Totals, Manufacturing Industry--1961	130
VII-22	Use of Electric Power Production by Segments	131
VII-23	Chemical Plants Possible of Development near Assab	140
VII-24	Power and Energy Requirements for Proposed Cement Factories	144
VII-25	Estimated Power Requirements for Factories Planned by 1967	147
VII-26	Tariff in Force, EELPA	152
VII-27	Specific Production Costs, Addis Ababa Steam Plant	153
VII-28	Comparison of Energy Costs in 1958 by Segments of Industry	154
VII-29	Energy Cost other than Electricity	155
VII-30	1961 Interconnected System--Addis Ababa Complex --Cases A and B	158
VII-31	1963 Isolated Systems--Case B	159
VII-32	1961 Interconnected System--Addis Ababa Complex --Cases A and B	159
VII-33	1961 Interconnected System--Addis Ababa Complex	160
VII-34	Past Trends of Energy Requirements (Excluding Eritrea and Production by Industrial Firms)	162
VII-35	Energy and Demand at Load Center--Addis Ababa Complex--Cases A and B	164
VII-36	Energy and Demand at Load Center--Agere Hiywet (Ambo)--Case B	167
VII-37	Energy and Demand at Load Center--Lekkemt--Case B	168

12

Number	Title	Page
VII-38	Energy and Demand at Load Center--Jima--Case B	169
VII-39	Energy and Demand at Load Center--Dessie--Case B	170
VII-40	Energy and Demand at Load Center--South Eritrea --Case B	171
VII-41	Sales by Classes--Addis Ababa Complex--Case A	172
VII-42	Estimated Peak Demand--Interconnected System--Addis Ababa Complex--Case A	173
VII-43	Sales by Classes--Agere Hiywet (Ambo)--Case B	174
VII-44	Sales by Classes--Lekkemt--Case B	175
VII-45	Sales by Classes--Jima--Case B	176
VII-46	Sales by Classes--Dessie--Case B	177
VII-47	Sales by Classes--South Eritrea--Case B	179
VII-48	Estimated Peak Demand--Interconnected System--Case B	180
VII-49	Dependable System Capacity to Meet Peak Demand versus System Coincidental Peak Demand at Plant--1964-1967--Case A or B	181
VII-50	Dependable System Capacity to Meet Peak Demand versus System Coincidental Peak Demand at Plant--1968-1980--Case A	183
VII-51	Dependable System Capacity to Meet Peak Demand versus System Coincidental Peak Demand at Plant--1968-1980--Case B	184
VII-52	Estimated Future Needs for Additional Capacity using Finchaa Sub-Basin Facilities--1968-1980--Case A	186
VII-53	Estimated Future Needs for Additional Capacity using Finchaa Sub-Basin Facilities--1968-1980--Case B	187
VIII-1	Summary of Costs and Annual Cost Equivalents--Finchaa Project	203
VIII-2	Specific and Joint Costs of the Finchaa Project	205
VIII-3	Allocation of Costs of the Finchaa Project by use of the Alternative Justifiable Method	206
VIII-4	Summary of Irrigation Costs--Finchaa Project	207
VIII-5	Summary of Power Costs--Finchaa Project	208

Number	Title	Page
VIII-6	Summary of Costs and Annual Cost Equivalents--Amarti-Neshe Project	211
VIII-7	Specific and Joint Costs of the Amarti-Neshe Project	212
VIII-8	Allocation of Costs of the Amarti-Neshe Project by Use of the Alternative Justifiable Method	213
VIII-9	Summary of Irrigation Costs--Amarti-Neshe Project	214
VIII-10	Summary of Power Costs--Amarti-Neshe Project	215
IX-1	Cash Requirement per Family	220

14

LIST OF DRAWINGS

Number	Title	Follows page
6.0-BN-27	Rainfall-Runoff Relationship in Blue Nile Basin	22
2.0-Fi-1	Area-Capacity Curves--Finchaa Reservoir	22
5.2-Fi-2	General Geologic Reconnaissance Map--Neshe-Finchaa Area	44
2.0-BN-92	Finchaa Sub-Basin--Location Map	46
2.0-Fi-2	Finchaa River Project--General Plan	46
2.0-Fi-9	Finchaa River Area--Topography (3 sheets)	46
4.0-BN-74	Profile of Finchaa River--Chomen Swamp Outlet to Mouth	46
OA-23-101	Finchaa Storage Dam and Finchaa Power Diversion Dam	46
2.2-BN-1	Finchaa Dam and Reservoir--Area-Capacity Data	48
4.0-Fi-5	Finchaa Storage Dam--Cross-Section at Damsite at Outlet of Chomen Swamp	48
4.0-Fi-9	Finchaa Power Diversion Dam--Cross-Section at Damsite on Finchaa River below Chomen Swamp	48
4.0-Fi-8	Finchaa River Powerplant--Switching Diagram	52
4.0-BN-23	Device Designations--Symbols for Switching Diagrams	54
4.0-BN-174	Gafarsa Substation No. 2--Switching Diagram--Stages 01 and 02	54
2.0-Fi-6	Amarti-Neshe Project--General Plan	60
OA-23-91	Neshe Dam and Amarti Dam--General Plans and Sections	60
2.2-BN-3	Neshe Dam and Reservoir (without Amarti)--Area-Capacity Data	62
2.2-BN-4	Amarti Dam and Reservoir--Area-Capacity Data	62

Number	Title	Follows page
2.0-Fi-14	Area-Capacity Curves--Amarti-Neshe Combined	62
2.0-Fi-7	Profile--Neshe River Damsite	64
2.0-Fi-8	Profile--Amarti River Damsite	64
4.0-BN-87	Neshe River Powerplant--Switching Diagram	64
7.1-Fi-3	Reconnaissance Land Classification and Soil Profiles--Finchaa River Area	80
2.0-Fi-13	Reconnaissance Land Classification and General Plan--Amarti-Neshe Project	80
4.0-BN-169	Map of Ethiopia--Electric Power Load Center--Addis Ababa Complex--Case A	106
4.0-BN-171	Map of Ethiopia--Electric Power Load Centers --Case B	106
4.0-BN-39	Estimated Population Trend--Electric Power Load Analysis	108
4.0-BN-40	Employment--Manufacturing Industries--Electric Power Load Analysis	110
7.2-BN-1	Land Utilization--Blue Nile River Basin	110
4.0-BN-29	Rural Population Density and Distribution--Blue Nile River Basin	110
4.0-BN-30	Gross Industrial Production--Small Industries	116
4.0-BN-31	Gross Industrial Production--Major Industries	116
4.0-BN-32	Total Gross Industrial Production	116
4.0-BN-33	Major Imports--Dollar Value	120
4.0-BN-37	Major Exports--Volume	120
4.0-BN-43	Major Exports--Dollar Value	120
4.0-BN-36	Ethiopia External Trade	120
4.0-BN-35	Building Construction--Addis Ababa	150
4.0-BN-79	Estimated Future per capita Electrical Energy Production Requirements in Ethiopia	156
4.0-BN-151	World Power Data--1961	156
4.0-Et-13	1961 Existing Interconnected System--Addis Ababa Complex	158
4.0-BN-170	Map of Ethiopia--Electric Power Facilities for Addis Ababa Complex, utilizing Finchaa Sub-Basin Powerplants	158

16

Number	Title	Follows page
4.0-Et-4	Daily Load Diagrams--Addis Ababa	160
4.0-Et-5	Load Characteristics--Principal Cities--Ethiopia (Excluding Eritrea)	162
4.0-BN-77	1961-62 Load Characteristics--Monthly Distribution--Interconnected System	162
4.0-BN-78	Future Load Characteristics--Monthly Distribution--Interconnected System	162
4.0-BN-118	Future Load Characteristics--Load Duration and Peak Percent Curves--Heavy Load Conditions--Interconnected System (Excluding Eritrea)	162
4.0-BN-148	Production of Electricity by Industrial Firms	182
4.0-Et-14	1971 Interconnected System--Addis Ababa Complex--Case A or B	186
4.0-Et-15	1980 Interconnected System--Addis Ababa Complex--Case A	188
4.0-BN-172	Estimated Peak Generation Requirements and Schedule of Powerplant Installations --Interconnected System--Case A	188
4.0-BN-173	Estimated Peak Generation Requirements and Schedule of Powerplant Installations --Interconnected System--Case B	188
4.0-BN-85	Alternative Thermal Power at Load Centers--Akaki Steam Plant	190
7.2-Fi-1	Preliminary Farm Layout--Finchaa Project	222
4.0-BN-175	Ethiopian Electric Light and Power Authority --Organization Chart, 1962	226
4.0-BN-176	Phase I Operations--Multiple-Purpose Projects --EELPA and WRD--Organization Chart	226
4.0-BN-177	Phase II Operations--Multiple-Purpose Projects --EP&WRA--Organization Chart	226

LIST OF PHOTOGRAPHS

	Follows page
Finchaa River Project--looking south	14
Amarti-Neshe Project--view upstream	44
Finchaa Damsite--looking downstream	46
Finchaa Falls Forebay Damsite--looking upstream	46
Neshe Damsite and Intervalley Basalt--looking upstream	60
Amarti Damsite--looking downstream	62
Neshe Powerplant Site--looking upstream	192

SECTION I - INTRODUCTION

SUMMARY

The Finchaa River Sub-Basin occupies an area of 3,500 square kilometers south of the Blue Nile in Wellegga Province. The Finchaa and its two main tributaries rise in large swamps on the high plateau and drop over a sharp escarpment into the deeply eroded lower Finchaa valley, which contains the lands considered in the development of a multipurpose power and irrigation project in this area. Physically, the project is divided into two parts--the Finchaa and the Amarti-Neshe. The Finchaa would utilize water supply from the Finchaa River, as it emerges from the Chomen Swamp, for power and for irrigation of lands upstream from the area that is drained by the Amarti and Neshe Rivers. The Amarti-Neshe Project would utilize the water from these rivers to develop power and to irrigate lands downstream from those to be irrigated from the Finchaa.

This report is primarily concerned with the Finchaa Project but, because of the proximity of the two projects and the interrelationship of data as collected, both projects are discussed in this volume. Only the Finchaa is discussed in this summary.

The Finchaa Project works would include a storage dam, a power diversion dam, a tunnel and penstocks to carry the water to a powerplant in the lower valley, a diversion dam for irrigation, and canals and laterals to irrigate about 15,000 hectares of land.

Project construction costs are estimated to be as follows.

Finchaa Dam	Eth$ 682,000
Power Diversion Dam	210,000
Tunnel and Penstocks	32,948,000
Powerplant	11,015,000
Transmission Plant	21,004,000
Irrigation Diversion Dam	545,000
Canals, Laterals, and Drains	15,567,000
Access Roads and Service Facilities	4,156,000
Total	Eth$86,127,000

20

The project lands lie at an elevation of about 1500 meters. The soils are well suited to irrigation development and are capable of producing sustained high yields. The topography of the area is lightly rolling with general slopes toward the Finchaa River which flows northward through the center of the wide valley. The soils contain no salts that would be harmful to growing plants, and it is not anticipated that any serious problems in subsurface drainage would develop if irrigation water is properly applied and normal precautions are taken. Excess surface water would be carried away by the existing drainage channels and by drains constructed for this purpose.

The project area, at the present time, is uninhabited and uncultivated, although the highlands on the plateau surrounding the area are populated and extensively farmed. The project lands are covered with low-growing trees, bush, and tall grass that would be removed as the project is developed. Land leveling and clearing costs are estimated to be Eth$5,325,000.

The climate of the project area is typical of this part of Africa with temperatures ranging from 6° C. to 39° C. (43° F. to 102° F.). The days are warm and the nights cool, although frosts do not occur. The rainfall in the area is about 1,000 millimeters annually, with the following general distribution by months.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
17.1	21.3	73.6	69.6	57.1	143.6	229.4	221.7	110.8	37.4	4.5	13.9	1,000.0

During the period from June through September, there is an overabundance of precipitation and the fields become too wet to be properly worked and cultivated by mechanical means. During the remainder of the year, the precipitation is not sufficient to meet the requirements for full crop production. To offset the normal shortages of rainfall, 954 millimeters of irrigation water would be required.

Under existing conditions in Ethiopia, farming operations are limited to an area that the farmer can cultivate with the tools and equipment available to him within his slender financial resources. It is recognized that, because of the lack of storage and transportation facilities, there is little current market for farm products in excess of requirements for family consumption and small amounts exchanged locally. This results in farms of about three or four hectares in area and a standard of subsistence lower than is desirable. The average annual farm income is estimated to be about Eth$170 to Eth$300. The primary objective of the IEG in the development of her resources is an improvement of the standard of living

21

of her people and an improvement in the national economy by increasing production. The project has been designed to provide modern farms of about 17 hectares in area, each capable of producing more food for family consumption, improving housing, providing opportunity for education of children, and permitting the farmer to acquire an equity in the land and set aside a small savings for emergencies and old age.

Farm products in excess of requirements of the farm family would be marketed to help support the increasing population with perhaps some products available for export to world markets.

During the period of initial development, a training program would be necessary to acquaint the farmers and the operators of the irrigation system with modern practices and equipment. The project at ultimate development would include approximately 880 individual farms. It is anticipated that many of the farmers would come from the agricultural college and schools. Few of the farmers will have the financial resources required to meet initial costs. Therefore, it will be necessary for initial capital to be made available to them.

The project can produce a wide variety of crops suitable to the climate and growing conditions. However, in order to present a more conservative view for the purpose of the economic analysis of the project, crops projected were mostly those commonly produced in Ethiopia and widely accepted in the Ethiopian diet. A few new crops were included for the export market and for gradual introduction into the Ethiopian diet and economy.

The annual value of crops produced is estimated to be about Eth$8,932,000. Since there is no production from the area at the present time, this amount is considered as the gross agricultural benefit resulting from the development of the project. Many intangible benefits will result, but no attempt has been made to place a monetary value on these.

The project will provide 880 new, independent farms with a stable population of about 4,000 persons in the farm families. In addition, it is estimated that a labor force of 13,000 persons would be required, or 61,000 people including families. Thus, about 65,000 persons would be supported directly by the agricultural sector of the project.

The Finchaa hydroelectric power facilities would have an installed generating capacity of 80,000 kw. and would produce 360,420,000 gross kw.-hr. annually to meet the expanding power requirements of the Interconnected System with loads centered mainly

22

at Addis Ababa. Power for the area is now produced by the Ethiopian Electric Light and Power Authority at plants on the Awash River. Two additional plants are planned by EELPA on the Awash, but even with these plants additional power will be required in 1971, either from a fourth Awash plant or from the Finchaa Project.

The powerplant would include two impulse-type turbines operating under a net head of 467 meters. A 250-kilometer, 161-kv. transmission line would be required to deliver power to the load centers and would tie into the existing EELPA facilities, thus forming an interconnected system.

It is assumed that initially the powerplant would be operated and the power marketed by the existing EELPA organization in cooperation with the Water Resources Department.

There is an adequate water supply for power and irrigation developments.

Benefit-Cost Comparison

Annual estimated irrigation benefits	Eth$ 8,936,000
Annual cost allocated to irrigation	2,006,000

$$\frac{8,936,000}{2,006,000} = 4.45 \text{ to } 1.00, \text{ benefit to cost ratio}$$

Annual estimated power benefits	Eth$16,400,000
Annual cost allocated to power	5,367,000

$$\frac{16,400,000}{5,367,000} = 3.06 \text{ to } 1.00, \text{ benefit to cost ratio}$$

Total annual benefits	Eth$25,336,000
Total annual cost	7,373,000

$$\frac{25,336,000}{7,373,000} = 3.44 \text{ to } 1.00, \text{ benefit to cost ratio}$$

The investigation covered by this report must be considered as a limited reconnaissance lacking the detail that would be required for the development of a definite plan upon which a project could be constructed, but adequate for the general plan and evaluation and for its intended purpose of assisting the Imperial Ethiopian Government in the selection of projects worthy of further detailed investigation.

It is recommended that the Imperial Ethiopian Government proceed with a further detailed study of the project.

CONCLUSIONS

1. The climate in the project areas is subtropical and well suited to the production of many crops and to the production of more than one crop each year.

2. The soils are generally deep, friable, permeable, medium to fine textured latosols, and are well suited to irrigation--particularly when properly fertilized.

3. Land slopes are slightly excessive for optimum irrigation conditions and the slopes of the lands are the principal reasons for downgrading land.

4. The moderately dense forest cover will need to be removed prior to irrigation, but the resulting wood should be useful for charcoal and firewood.

5. Construction of project irrigation works will be quite expensive because of the many drainage crossings needed.

6. Erosion hazards are fairly high and considerable care must be used in irrigation application and water disposal to maintain a permanent irrigated agriculture.

7. Regardless of the extent of system interconnections that would be possible by the year 1980, the Finchaa power facilities are required to be in service during the year 1974. The Neshe power facilities will be required in 1977 or 1978, with the output of both powerplants plus the four Awash plants providing for the needs of the Interconnected System through 1980 or 1981.

The Finchaa and Neshe projects are multipurpose, but the potential hydroelectric power facilities are such that they can be developed in advance and independently of the irrigation facilities without being prejudicial to the interests of the irrigation features of the project. Hydroelectric powerplant requirements determine the maximum capacity of the water storage facilities and waterways so that advance construction of the hydroelectric facilities would not affect the later construction of the separate irrigation facilities downstream. If this is contemplated, the multiple-purpose nature of the projects must not be lost sight of, and a part of the income from power revenues should be set aside for complete project development whenever that might occur.

8. The Finchaa Project is attractive in another respect in that another electrically identical powerplant (Neshe) can be constructed nearby with both powerplants connected to the Addis Ababa Complex by a

24

single, steel tower, transmission line carrying two circuits, or by a higher voltage line carrying only one circuit. (See SECTION V.)

9. The sites are geologically suitable for the proposed dams, powerplants, and appurtenant structures.

RECOMMENDATIONS

1. A detailed land classification study should be made prior to construction. Among other things, this study should (1) delineate the topographic variables accurately; (2) determine the needs for subsurface drainage construction; (3) separate and appraise productivity potentials for the various types of soils; (4) ascertain a more exact cost of tree and brush clearing and land leveling; (5) study the erosiveness of the soils and determine the need for and cost of erosion control; (6) determine the type and quantity of fertilizer or soil amendments needed for maximum production; and (7) determine the method of irrigation best suited to the land and people.

2. An experimental farm should be established early in the development period to determine the best crops and agricultural practices to use.

3. Future studies should include a study of the anticipated irrigation water quality and the effects that such water will have on the project soils.

4. Any initial irrigation development should avoid developing the bottoms or lower side slopes of any deep drainageways because of the danger that these areas will become waterlogged when the adjacent higher lands are irrigated.

5. During preconstruction investigations the foundations for dams and other structures should be explored by a core drilling program to establish the depths to and the permeability of the intervalley volcanic material. Potential borrow areas should be sampled and analyzed, and detailed geologic maps prepared for all of the structure sites.

6. Awash No. 4 should not be constructed following Awash No. 3, if at all possible; and, with this in mind, every effort should be made to expedite the engineering and economic feasibility studies for the Finchaa Project with the objective of having the power facilities in operation by the end of 1971 instead of during 1974. By that time, enough operating experience with the Koka reservoir and Awash River should have been accumulated to determine

25

whether Awash No. 4 should be constructed. If construction of Awash No. 4 is justified, this could be done after the Finchaa or Neshe project development, because by then the hydroelectric powerplants will not all be in one river basin.

7. Compilation of hydrological data must be expanded and continue uninterruptedly on the Finchaa, Neshe, and Amarti Rivers to provide firmer data upon which to base final project plans.

8. It is recommended that topographic surveys be performed to about a 1-meter contour interval on the project area, and about a 5-meter interval on the drainage area. Construction materials should be further investigated and ascertained. The construction cost estimates, especially as they apply to unit prices, should further be refined.

9. Malaria and the tsetse fly are a hazard to the project and control measures should be introduced prior to project development. Agricultural and economic studies should be further expanded and continued.

26

SECTION II - GENERAL DESCRIPTION

Basin Description

The Finchaa River Sub-Basin is located in the south central portion of the Blue Nile River Basin. It is bounded on the south by the Great Gibe River Basin, on the north by the Abbay (Blue Nile) River, on the west by the Diddessa Sub-Basin, and on the east by the Guder drainage area. Roughly resembling an arrowhead in shape, the subbasin is distinguished by the Chomen Swamp, a vast flat area lying on the plateau between the mountains and a precipitous escarpment. Situated at an elevation of 2210 meters (7250 feet) above sea level, the Chomen Swamp is fed by numerous small streams which head in the high hills (highest of which is at an elevation of 3000 meters or 9840 feet above sea level) and emerge at the northeastern end of the swamp as the Finchaa River. The gradient throughout the swamp is so flat that drainage systems are not well established, and during the rainy season and for a long period after the rains have ended, the area is essentially a large, shallow lake containing water grass, papyrus, reeds, and other water vegetation. Above the swamp, the slopes and rounded ridges are cultivated for raising grain crops.

From the outlet, the Finchaa River meanders generally in an easterly direction for about five kilometers, where, at the brink of the plateau, it plunges over an escarpment in two prominent waterfalls, falling some 500 meters (1,640 feet) in two kilometers. Below the falls, the water then cascades for several kilometers through a steep canyon. Downstream from the steep canyon section, the stream gradient again flattens and the valley widens. Along the sides of this reach of the river gentle slopes are covered with deep soil, which potentially could be developed into an irrigation project. These slopes are covered with very tall grass and scattered trees and brush. Few, if any, people live in this area, perhaps because it is infested with tsetse flies and mosquitoes. There is only one important tributary to the Finchaa River--the Neshe, having its headwaters to the west of the lower valley. The Amarti River, a tributary of the Neshe, and the Neshe River drain an area composed typically of high mountains, steep slopes, and rough topography. The two rivers flow into long, narrow valleys with a slight gradient, forming narrow swampy areas, and then drop over the edge of the

27

escarpment to form the Neshe River, which in turn flows into the Finchaa near its confluence with the Blue Nile.

Projects Area Description

The area under consideration is the lower valley, bounded on the southwest and the east by a sandstone escarpment (in places, lava capped), on the north by rough breaks along the Blue Nile River canyon, and on the west in the lower portion of the valley by a low saddle forming a divide between the Finchaa Project area and the Amarti-Neshe Project area. It is situated about 1500 meters above sea level (500 meters below the escarpment) and is about 12 kilometers (7.5 miles) wide and 37 kilometers (23 miles) in length. The valley is fairly well covered with dense growth of tropical savannah woodland, interspersed with a very dense growth of tall grass. The stream bottoms of the tributaries support a dense growth of tall trees, which reach a height of 30 meters (100 feet). Shrubs and bushes are interspersed throughout the bottoms. The valley is uninhabited and uncultivated, probably due to the heat and the unfavorable health conditions, as tsetse flies were observed and undoubtedly malaria is prevalent.

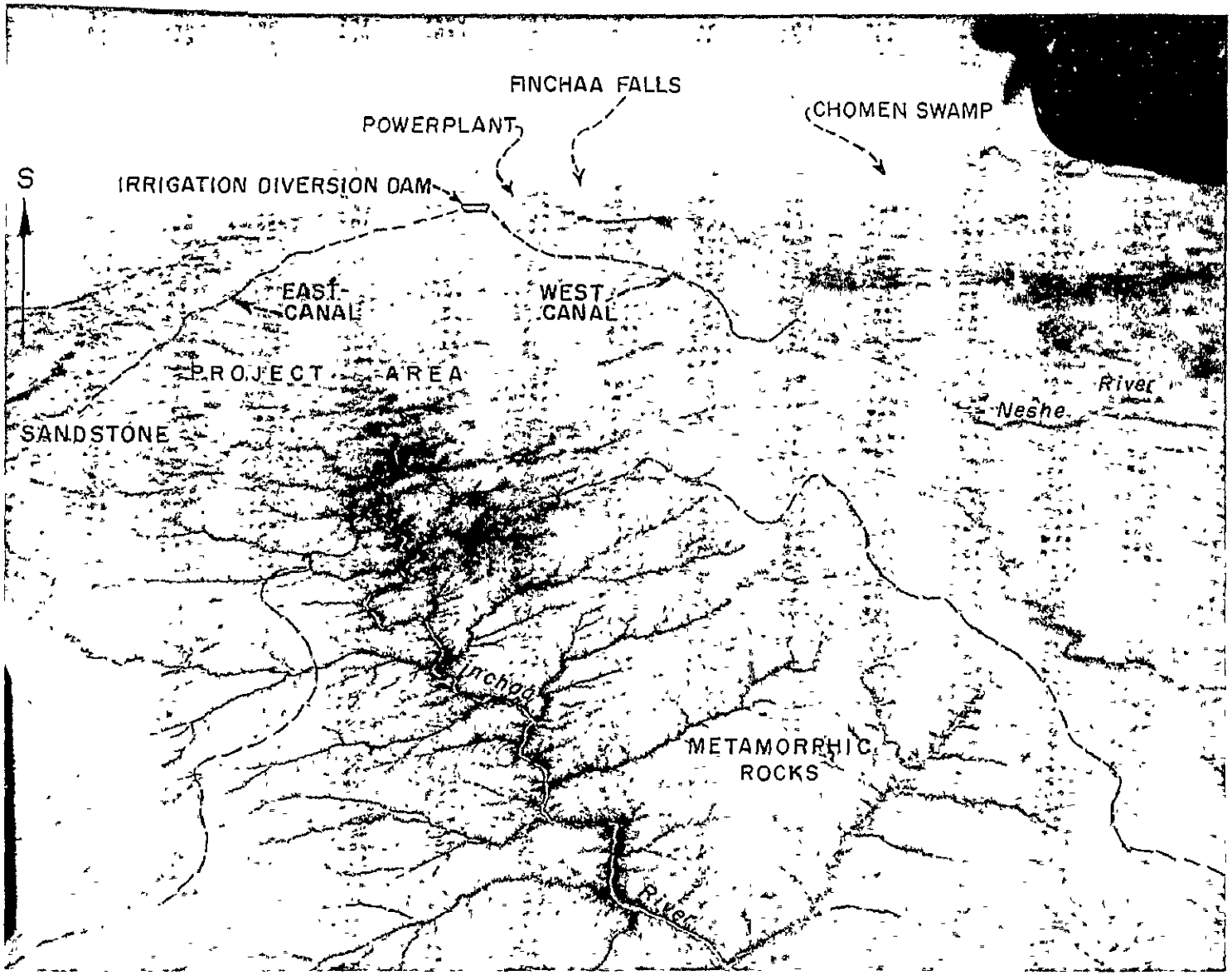
The Finchaa River bisects the valley, and its many tributaries generally approach and enter the main stream at right angles to the south-north direction of the river's flow. The tributaries are entrenched from three to ten meters into the valley soil. These channels do not have precipitous side slopes as a rule but tend toward somewhat rolling topography. The higher lying land areas are fairly large, about 700 hectares (1,700 acres), and the streams provide adequate outlets for surface runoff. The slopes on these areas are usually quite gentle and smooth in surface relief. Steep slopes and dissected rough lands occur at the head of the valley where the escarpment forms a canyon.

Population

The Finchaa valley is uncultivated and uninhabited, but evidence of former cultivation is present. The climate is somewhat warmer than most highland Ethiopians prefer, but the area apparently was abandoned because of the historic memory and fear of potential recurrence of human and animal disease. The presence of such inimical insects as the Anopheles malarial mosquito and the tsetse fly, which can transmit encephalitis or sleeping sickness, keep the valley empty of human habitation. Some paths and many game trails exist in the area, but there are no roads or buildings.

Present Economy

At present, the lower valley of the Finchaa, Amarti, and Neshe Rivers may be said to have no economy. The area is unpopulated;



FINCHAA RIVER PROJECT-LOOKING SOUTH

it is neither farmed or grazed on a permanent or shifting basis; no important amount of wild products is gathered; and the amount of hunting, fishing, and trapping is negligible.

Climate

The climate in the lower valley, where the project development is contemplated, is warm and subtropical, favorable to the raising of a wide variety of crops, including such subtropical types as oil seeds, cereal crops, and coffee. Average annual precipitation is uncertain, but is estimated at 100 centimeters, the bulk falling in the rainy season--July through September. The average annual temperature will be about 22° Centigrade (72° Fahrenheit). Although frost is not expected, autumn nights tend to be cool, and strictly tropical crops probably will not do well. On the other hand, the lack of frost precludes raising those temperate deciduous crops that require freezing temperatures for dormancy.

Table II-1 shows averages of July and January and annual records for temperature and precipitation at 16 stations in the Blue Nile Basin. Most of these stations are in the upland, more inhabited area, and none lies below the escarpment in the Finchaa Basin. Inspection of Tables II-2, II-3, and II-4, which show monthly averages of temperature and monthly totals of precipitation at Ambo over the 1951 through 1961 period, may afford a basis for estimating how weather varies on the potential service area. It is recommended that a climatological station be established immediately in the Finchaa area and that applicable records be taken regularly.

By referring to climatic data, farm delivery requirement on the potential service area has been estimated as shown in Table III-2. To these farm-delivery requirements, 20 percent has been added to allow for operational waste, and seepage losses were also provided for as mentioned within narratives for the Finchaa and the Amarti-Neshe project descriptions.

Quality of Water

Quality-of-water samples were taken throughout the annual fluctuation of flow at several widely spaced locations in the Blue Nile Basin. They all show good to excellent quality for irrigation purposes, primarily because most of the bedrock in the upland area is basic, igneous material which does not produce deleterious amounts of salt, and also because the steep, fine grained, soil mantle produces high percentages of surface runoff, so that there is a minimum exposure of subsurface flow to rocks which could produce significant amounts of dissolved salts in the total flow. Both the Finchaa and the Amarti-Neshe Projects fit this general description, and it is

therefore predictable that a more detailed sampling program would show the flows to be of good or excellent chemical quality for irrigation.

TABLE II-1

CLIMATIC STATIONS IN OR NEAR ABBAY BASIN IN ETHIOPIA

Station	Elevation in Meters	Temperature in degrees centigrade Average of daily maxima		Temperature in degrees centigrade Average of daily minima		Precipitation in millimeters Average for		
		Jan.	July	Jan.	July	Jan.	July	Year
Addis Ababa	2,408	24	20	6.9	10.2	21.9	252.0	1,142.5
Ambo Ag. Col.	2,130	27	22	10.9	12.0	18.4	246.8	1,075.3
Arjo	2,565	-	-	-	-	13.8	321.8	1,756.4
Asosa	1,665a/	31	23	14.0	14.8	0	281.6	1,253.0
Bahir Dar	1,802	26	24	8.9	13.4	0	309.2	1,051.8
Dangila	2,107a/	29	26	3.3	9.9	0.8	359.2	1,468.9
Debre Birhan	2,840	21	21	8.7	11.5	20.5	323.0	925.2
Debre Markos	2,313	24	18	7.4	9.8	20.8	331.0	1,416.3
Debre Tabor	2,945	26	23	5.8	8.0	7.2	518.3	1,714.9
Fiche	2,820	19	15	7.8	8.9	11.9	497.3	1,398.4
Galabat	765	-	-	-	-	0	199.9	877.8
Gimbi	1,988a/	30	24	16.4	11.8	22.9	336.5	2,151.9
Gondar	2,121	28	21	10.0	13.2	3.1	319.2	1,213.0
Jima Ag. Col.	1,701a/	27	21	9.9	13.4	33.8	214.2	1,551.0
Kembolcha	1,903	24	26	10.0	13.7	31.3	295.6	1,104.2
Lekkemt	2,005	24	20	10.8	10.4	16.2	368.8	2,028.6
Mendi	1,767a/	26	22	12.9	13.8	7.8	296.3	1,763.1
Nejo	1,900	27	20	13.3	13.3	2.9	321.4	1,892.0

a/Elevation from C & GS benchmark; not identical with station.

32

TABLE II-2

TEMPERATURE AT AMBO AGRICULTURAL SCHOOL IN DEGREES CENTIGRADE

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL	Percent MEAN
						Average of Daily Minima								
1954	9.3	12.7	13.4	12.9	12.3	11.8	11.9	11.7	10.9	10.0	9.9	10.0	136.8	11.4
1955	11.9	10.8	11.6	13.0	11.8	11.3	11.8	11.2	11.6	10.4	10.4	11.1	137.9	11.5
1956	10.9	11.1	13.5	13.5	11.8	11.3	12.1	11.9	11.5	11.3	8.8	9.5	137.2	11.4
1957	9.8	11.4	12.2	12.5	12.0	10.7	11.6	11.7	11.0	11.5	11.9	11.1	137.4	11.5
1958	13.2	10.0	13.4	13.5		12.4	13.0	12.5	12.4	10.0				
1959	12.1		12.8	12.9	12.5	11.3	12.3	12.2	11.4	11.3	9.6	10.1		
1960	10.0	11.8	11.9	11.7	11.9	10.7	11.6	11.8	10.2	10.5	9.4			
1961	10.0	11.5	12.0	11.5	10.0									
Total	87.2	79.3	100.8	101.5	82.3	79.5	84.3	84.0	79.0	75.0	60.0	51.8		
Average	10.9	11.3	12.6	12.7	11.8	11.4	12.0	12.0	11.3	10.7	10.0	10.4	137.1	11.4

TABLE II-3

TEMPERATURE AT AMBO AGRICULTURAL SCHOOL IN DEGREES CENTIGRADE
Elevation 2,130 meters

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT	OCT.	NOV.	DEC.	TOTAL	Percent MEAN
						Average Daily Temperature								
1954	18.0	20.3	20.4	20.5	19.8	17.6	16.8	16.7	16.5	17.2	17.6	17.9	219.3	18.3
1955	18.8	19.5	20.3	20.2	19.4	17.7	16.5	16.7	17.1	17.6	17.8	18.0	219 6	18.3
1956	18.3	19.5	21.1	19.9	19.2	17.4	16.4	16.5	17.3	17.1	16.2	17.5	216.4	18.0
1957	18.8	18.8	18.2	19.2	19.2	17.8	16.8	16.7	17.6	19.2	19.5	18.9	220.7	18.4
1958	20.1	18.5	21.2	20.9					19.2	18.9				
1959	20.6													
1960	18.4	19.8	19.9	20.3	19.2	17.6	16.9	17.1	16.3	18.2	18.2			
1961	18.3	19.2	19.8	18.8	19.4									
Total	151.3	135.6	140.9	139.8	116.2	88.1	83.4	83.7	104.0	108.2	89.3	72.3	1,312.8	
Average	18.9	19.4	20.1	20.0	19.4	17.6	16.7	16 7	17.3	18.0	17.9	18.1	220.1	18 4
						Average of Daily Maxima								
1954	26.7	27.9	27.4	28.1	27.3	23.3	21.7	21.6	22.1	24.3	25.2	25.8	301.4	25.1
1955	25.6	28.2	28.9	27.4	27.0	24.1	21.2	21.2	22.5	24.8	25.2	24.8	300.9	25.1
1956	25.6	27.8	28.7	26.2	26.5	23.4	20.6	21.1	23.1	22.9	23.5	25.4	294.8	24.6
1957	27.7	26.2	24.1	25.8	26.3	24.8	21.9	21.7	24.2	26.9	27.0	26.7	303.3	25.3
1958	27.0	26.9	29.0	28.3					26.0	27.7	27.6	27.5		
1959	29.0	30.1												
1960		27.7	21.9		26.5	24.4	22.2	22.3	22.4					
1961	26.5	26.9	27.5	26.0	28.8									
Total	188.1	221.7	187.5	161.8	162.4	120.0	107.6	107.9	140.3	126.6	128.5	130.2		
Average	26.9	27.7	26.8	27.0	27.1	24.0	21.5	21.6	23.4	25.3	25.7	26.0	303.0	25.3

34

TABLE II-4

PRECIPITATION IN MILLIMETERS AT AMBO AGRICULTURAL SCHOOL

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
1951	0.0	52.0	109.0	42.5	72.0	200.5	200.0	199.0	107.0	48.0	2.0	31.0	1,063.0
1952	0.0	15.0	40.5	116.0	64.0	129.3	211.2						576.0
1954	0.0	12.5	79.4	51.0	33.4	141.7	241.1	245.4	152.9	19.5	1.0	3.5	981.4
1955	60.9	4.9	25.3	66.7	44.0	174.7	352.6	229.7	148.0	17.2	3.1	8.8	1,135.9
1956	11.2	8.9	43.4	92.5	66.5	161.2	173.7	286.2	125.1	158.8	2.2	7.4	1,137.1
1957	0.6	46.6	196.3	101.9	99.9	99.1	315.3	185.2	82.2	0.0	0.8	8.5	1,136.4
1958	49.5	0.0	109.4	101.2	19.3	195.8	245.4	187.3	74.3	29.6	0.0	33.0	1,044.8
1959	58.0	21.9	40.5	46.4	78.9	119.8	231.8	304.2	122.8	47.7	29.7	18.5	1,120.2
1960	4.1	60.4	62.8	90.9	106.4	167.9	250.4	271.1	140.6	1.1	0.0	8.3	1,164.0
1961	0.1	6.9	84.3	38.5	30.1								159.9
Total	184.4	229.1	790.9	747.6	614.5	1,390.0	2,221.5	1,908.1	952.9	321.9	38.8	119.0	9,518.7
Average	18.4	22.9	79.1	74.8	61.4	154.4	246.8	238.5	119.1	40.2	4.8	14.9	1,075.3
1962	No record												

25

SECTION III - HYDROLOGY

FINCHAA PROJECT

Operation Study

Finchaa Dam would be constructed on the Finchaa River at the Chomen Swamp outflow point, and power would be developed at the falls between the reservoir and the service area. During the irrigation season, intervening tributaries would produce no divertible flow. The principal hydrographic problem is whether a loss or a gain in consumption will result from providing a reservoir where there is now a swamp. Rain falling on a water surface would ordinarily be expected to yield a higher percentage of runoff than rain falling on land. However, the fact that records of the Finchaa and Abbay below Tana show relatively low yields per unit of drainage area suggests that present consumption is much greater on lake and swamp surfaces than for the land area (see Dwg. No. 6.0-BN-27). The Dabus may also be considered to have a low yield. Dabus is in the highest rainfall belt and would fall well above the curve, if swamp losses did not pull the yield down to normal.

The boundary of Chomen Swamp recedes as the dry season progresses, and there may be 30 or 40 centimeters of soil moisture lost to evaporation and transpiration after the surface is unwatered. On most of the lake, grass or fronds extend through the water, even in September when content reaches maximum; and rainy season consumption is probably as great as, or greater than, it would be on a lake of the same area. In fact, grass may be expected to extend to much of the lake surface, even after a reservoir is constructed. But there will be some area where the water is too deep for grass to survive during the period of maximum content, and consumption in this area may decline as a consequence of building the reservoir. Not knowing what the net effect of all these factors will be, the operation study was made on the assumption that future annual consumption with a reservoir would equal past annual consumption without a reservoir.

Estimate of Available Flow

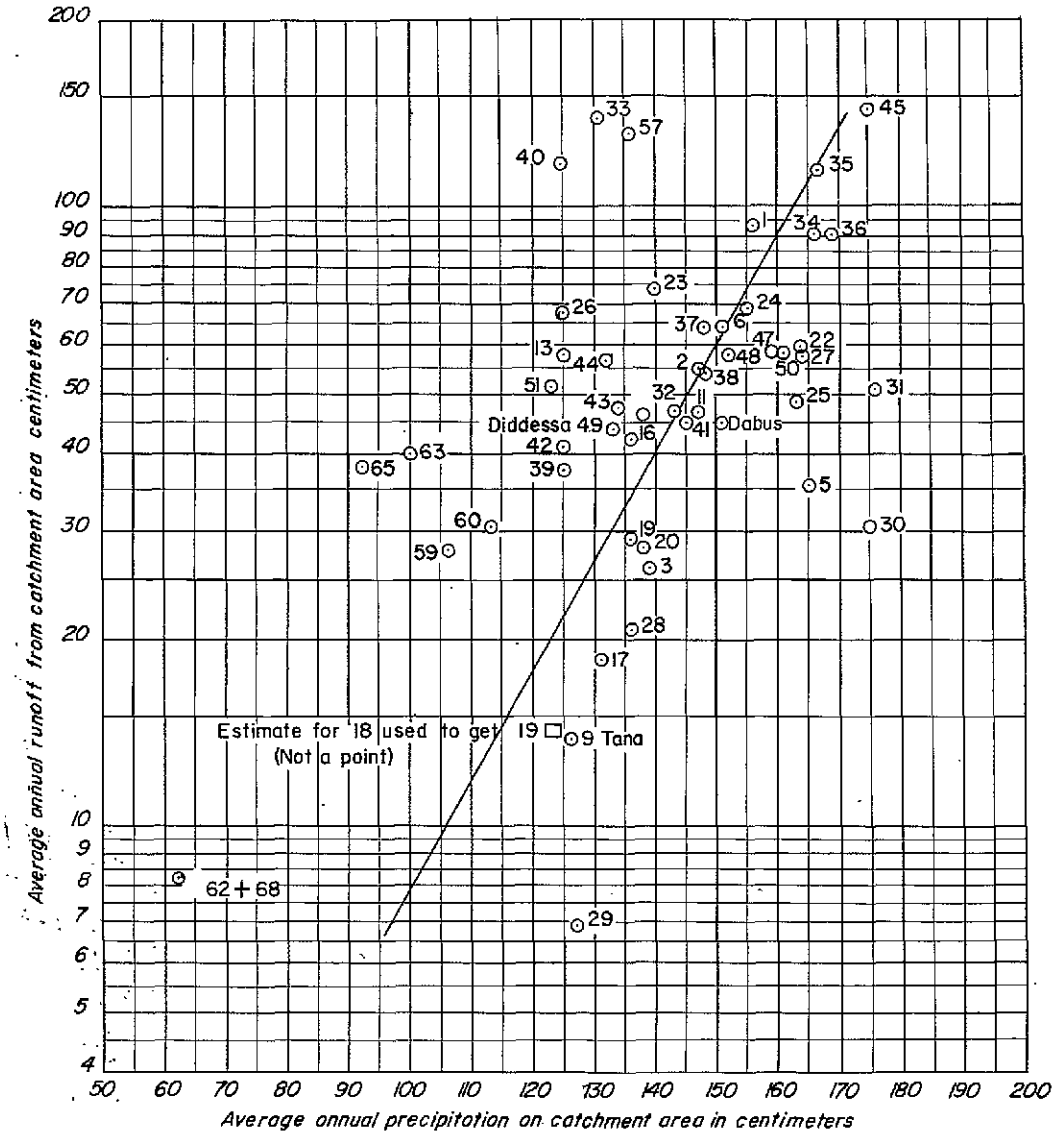
There are four years of record at the damsite. Flow available during other years was estimated by a monthly correlation with the record of the Abbay River at Kese. A correlation made directly with the Abbay at Roseires record might have been preferable, but concurrent records were unavailable when the operation study was initiated. Because of regulation by the swamp, the Finchaa River probably should have been shown to yield lesser flows in relation to Abbay flows, when monthly Abbay flows exceed six billion cubic meters. However, the difficulties of estimating losses in the swamp made it appear improbable that any considerable refinement could be secured. There is no question that the facilities as outlined will serve the 15,000-hectare Finchaa Project service area without shortage, and power yields during most periods will equal those shown in the study. If, after further study or with operating experience, it becomes apparent that a drought period could impair power production, additional water may be imported to maintain the yield. A canal above the escarpment, one or two kilometers in length, would be adequate for diverting Kontor Creek into Chomen Swamp at approximate longitude 37°20' E, latitude 9°10' N. Also, the Amarti-Neshe Project studies show that the Neshe River will produce more flow than is required on that service area. Should additional records show Finchaa flow short and Neshe in surplus, the boundary between their service areas can be shifted southward.

Some additional yield could be secured by providing dug channels at the swamp inlets. However, if this is attempted, it should be done with caution. Perhaps one inlet could be canalized; then, after ten or twenty years, if the net result appeared advantageous, others could be canalized. The swamp appears to be on slopes adequate to maintain velocities of perhaps one meter per second in a channel. Many of the inlets have channels extending for some distance into the swamp; and, at the lower elevations, there are channels through the swamp in which velocities at times of maximum content appear to reach about one meter per second. Although the swamp is on a grade, velocity over its remainder is retarded by the grass. Possible effects of connecting each inlet channel with the main outlet channel would be reduction in consumption by grass and evaporation around the upper edges of the proposed reservoir; transportation of silt, which might otherwise be deposited in grass above the high water line, into the reservoir; minor amounts of erosion in and near the upper ends of the channels; less natural irrigation and therefore lesser volume growth of grass near the edges of the swamp; and a change, perhaps for the better, in species and quality of grass in such areas.

Area-Capacity Relationships

The area-capacity curve (Dwg. No. 2.0-Fi-1) is based upon a minimum of data. The Finchaa Reservoir operation study (Table III-1)

31



NOTES

Reasons for dispersion of points:

1. Errors in rainfall data and their interpretation on map.
2. Areas of smaller drainage basins are known only to ± 50 percent.
3. Average annual flows are estimated from less than one year of record in some instances. Average record is about 1.5 years.
4. More Oct. to May rainfall in south-west produces higher percentage use there.

REVISED MAY 2, 1963

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., A.I.D AND U.S. DEPT. OF INT., BUR. OF RECL.

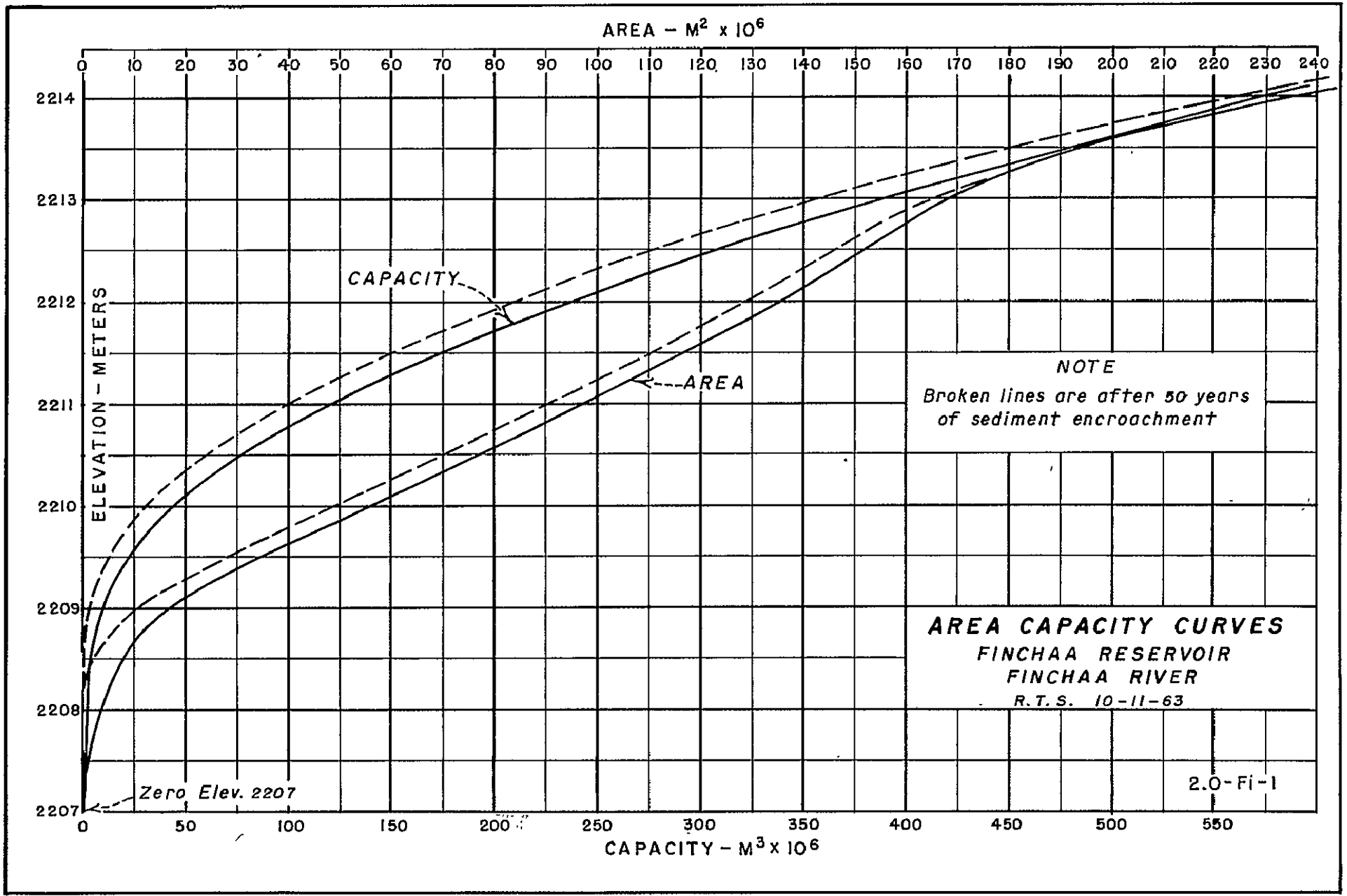
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

RAINFALL—RUNOFF RELATIONSHIP IN BLUE NILE BASIN

DRAWN KRAMER SUBMITTED Kramer
TRACED A. N. MUSSA RECOMMENDED Gangon
CHECKED Admasu M APPROVED R. Burdick

Addis Ababa Ethiopia MAR. 13, 1963 6.0-BN-27


AREA – M² x 10⁶
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240
ELEVATION – METERS
2214
2213
2212
2211
2210
2209
2208
2207
CAPACITY
AREA
Zero Elev. 2207
0 50 100 150 200 250 300 350 400 450 500 550
CAPACITY – M³ x 10⁶
NOTE
Broken lines are after 50 years of sediment encroachment
AREA CAPACITY CURVES
FINCHAA RESERVOIR
FINCHAA RIVER
R.T.S. 10-11-63
2.0-Fi-1

was made with a maximum content of 414.42 million cubic meters and a minimum content of 33.00 million cubic meters, or active capacity was 381.42 million cubic meters. Subsequently, plans for the dam (Dwg. No. OA-23-101) were laid out showing distribution of sediment expected during the first fifty years of operation, and capacities after 50 years of operation. The spillway crest was set at elevation 2213.4 (capacity at 50 years, 431.3 million cubic meters), and the minimum operation level required to serve the project needs was put at elevation 2210.0 (capacity at fifty years, 31.2 million cubic meters). Thus, with this dam, active capacity after fifty years of sedimentation is estimated as 400.1 million cubic meters (slightly greater than the 381.42 million cubic meters requirement shown by the operation study). After 100 years, the elevation of sediment at the dam is expected to be 2208.85 meters.

Monthly Power Releases

Releases were made in the operation study to produce power under a level load curve. This release was just adequate to meet irrigation requirements in the month of December with an excess in all other months. The average effective head is 467 meters after allowing for average friction losses, and generation is 361 million kilowatt-hours yearly after allowing for an 80 percent average turbine-generator efficiency.

Irrigated Area

Estimated farm delivery requirement, as shown in Table III-2, is 0.954 meter (3.13 feet). Allowing 12 percent for canal seepage and 20 percent for operational waste, the operation study shows that, if the reservoir is constructed to the estimated dimensions, 15,000 hectares (37,064 acres) of land can be irrigated with no shortages.

Spillway Design Flood

Ordinates of the maximum probable inflow flood are shown on Table III-3.

Flood Frequency

Frequency of floods to be anticipated during construction is shown on Table III-4.

Outlet Capacity

Table III-1 shows a minimum content in July 1914, when required release would have been 30.61 million cubic meters. The forebay at the head of the penstock is adequate for peaking; and outlet capacity should therefore be 11.4 cubic meters per second with water surface at the minimum operating level of 2210 meters, which is required to clear the 100-year sediment level and discharge 11.4 cubic meters per second.

AMARTI-NESHE PROJECT

Operation Study

Amarti yield will be diverted through a cut having an invert elevation of 2229 meters to the Neshe reservoir and outlet. Neshe floods will be diverted through the same cross channel to the Amarti spillway.

As shown in the operation study, Table III-5, minimum content is 165 million cubic meters and maximum is 751 million, and the required active content after 50 years of sedimentation and above the minimum operating level is 586 million cubic meters (475,000 acre-feet).

Estimate of Available Flow

On the basis of four current-meter measurements made on each stream in 1962, flows of the two streams have been estimated to total the amounts shown in column 2 of Table III-5. Gages have since been established. Several years of record will be necessary to prepare an operation study adequate for use in final, detailed plans.

Area-Capacity Relationships

The combined area-capacity table for the two reservoirs as anticipated after 50 years of sedimentation is shown on Table III-6, sheet 5. Assuming a cross-channel invert elevation of 2229 meters, each capacity item in this table includes 8.1 million cubic meters of inactive content in Amarti reservoir below elevation 2229.

After 100 years of operation, sediment at Neshe dam is expected to have a surface elevation of 2184.3 meters (7166 feet).

Elevation of sediment at Amarti dam and at the cross channel after 100 years of operation is expected to be 2228.6 meters (7312 feet).

Monthly Power Releases

Canal water surface immediately above the penstock is expected to be 2205 meters. Jet nozzle elevation for the power release is estimated as 1625 meters. Average effective head is estimated to be 560 meters after allowing for an average penstock loss of 20 meters.

TABLE III-1 Sheet 1 of 3

RESERVOIR OPERATION STUDY

FINCHAA RESERVOIR FINCHAA RIVER

Min STORAGE	Max ELEVATION	Max STORAGE	
33,000,000 cu m (26,756 ac-ft)	2,213.13 m (7,261 ft)	414,420,000 cu m (335,970 ac-ft)	Net power head = 467 m 360,480,000 kw-hr per yr at 80% eff.

FIRM YIELD 210,450,000 cu m per yr (irrig) 15,000 hectares
Max 354,250,000 cu m per yr (power) (37,100 acres)

Year	Months	Required power release	Power generation kw-hr x 10'	Inflow	Irrigation release	Additional release for power	Spill	Change in storage	End of month reservoir storage
		1	2	3	4	5	6	7	8
									414.42
1911	Oct.	30.08	30.61	99.00	20.81	9.27	68.92	0	414.42
	Nov.	29.14	29.65	54.70	28.24	0.90	25.56	0	414.42
	Dec.	30.08	30.61	29.50	30.08	0	0	-0.58	413.84
1912	Jan.	30.08	30.61	15.30	29.99	0.09	0	-14.78	399.06
	Feb.	28.14	28.63	8.80	26.99	1.15	0	-19.34	379.72
	Mar.	30.08	30.61	5.20	24.87	5.21	0	-24.88	354.84
	Apr.	29.14	29.65	4.00	25.64	3.50	0	-25.14	329.70
	May	30.08	30.61	2.90	23.83	6.25	0	-27.18	302.52
	June	29.14	29.65	2.50	0	29.14	0	-26.64	275.88
	July	30.08	30.61	13.90	0	30.08	0	-16.18	259.70
	Aug.	30.08	30.61	50.70	0	30.08	0	+20.62	280.32
	Sept.	29.14	29.65	102.00	0	29.14	0	+72.86	353.18
TOTALS		355.26	361.50	388.50	210.45	144.81	94.48	-61.24	-

1912	Oct.	30.08	30.61	70.00	20.81	9.27	0	+39.92	393.10
	Nov.	29.14	29.65	31.00	28.24	0.90	0	+1.86	394.96
	Dec.	30.08	30.61	15.30	30.08	0	0	-14.78	380.18
1913	Jan.	30.08	30.61	9.00	29.99	0.09	0	-21.08	359.10
	Feb.	27.13	27.61	5.20	26.99	0.14	0	-21.93	337.17
	Mar.	30.08	30.61	4.00	24.87	5.21	0	-26.08	311.09
	Apr.	29.14	29.65	3.80	25.64	3.50	0	-25.34	285.75
	May	30.08	30.61	3.00	23.83	6.25	0	-27.08	258.67
	June	29.14	29.65	5.80	0	29.14	0	-23.34	235.33
	July	30.08	30.61	4.30	0	30.08	0	-25.78	209.55
	Aug.	30.08	30.61	21.90	0	30.08	0	-8.18	201.37
	Sept.	29.14	29.65	55.50	0	29.14	0	+26.36	227.73
TOTALS		354.25	360.42	228.80	210.45	143.80	0	-125.45	-

Sept. 1962

Year	Months	Required power release	Power generation kw-hr x 10^6	Inflow	Irrigation release	Additional release for power	Spill	Change in storage	End of month reservoir storage
		1	2	3	4	5	6	7	8
									227.73
1913	Oct.	30.08	30.61	52.00	20.81	9.27	0	+21.92	249.65
	Nov.	29.14	29.65	20.00	28.24	0.90	0	-9.14	240.51
	Dec.	30.08	30.61	7.00	30.08	0	0	-23.08	217.43
1914	Jan.	30.08	30.61	3.90	29.99	0.09	0	-26.18	191.25
	Feb.	27.13	27.61	2.30	26.99	0.14	0	-24.83	166.42
	Mar.	30.08	30.61	2.10	24.87	5.21	0	-27.98	138.44
	Apr.	29.14	29.65	2.30	25.64	3.50	0	-26.84	111.60
	May	30.08	30.61	2.40	23.83	6.25	0	-27.68	83.92
	June	29.14	29.65	2.30	0	29.14	0	-26.84	57.08
	July	30.08	30.61	6.00	0	30.08	0	-24.08	33.00
	Aug.	30.08	30.61	49.00		30.08	0	+18.92	51.92
	Sept.	29.14	29.65	128.00	0	29.14	0	+98.86	150.78
TOTALS		354.25	360.48	277.30	210.45	143.45	0	-76.95	-

1914	Oct.	30.08	30.61	85.30	20.81	9.27	0	+55.22	206.00
	Nov.	29.14	29.65	71.00	28.24	0.90	0	+41.86	247.86
	Dec.	30.08	30.61	40.90	30.08	0	0	+10.82	258.68
1915	Jan.	30.08	30.61	16.30	29.99	0.09	0	-13.78	244.90
	Feb.	27.13	27.61	9.00	26.99	0.14	0	-18.13	226.77
	Mar.	30.08	30.61	5.00	24.87	5.21	0	-25.08	201.69
	Apr.	29.14	29.65	4.00	25.64	3.50	0	-25.14	176.55
	May	30.08	30.61	2.40	23.83	6.25	0	-27.68	148.87
	June	29.14	29.65	5.20	0	29.14	0	-23.94	124.93
	July	30.08	30.61	12.00	0	30.08	0	-18.08	106.85
	Aug.	30.08	30.61	32.30	0	30.08	0	+2.22	109.07
	Sept.	29.14	29.65	66.30	0	29.14	0	+37.16	146.23
TOTALS		354.25	360.48	349.70	210.45	143.80	0	-4.55	-

Sept. 1962

Year	Months	Required power release	Power generation kw-hr x 10^6	Inflow	Irrigation release	Additional release for power	Spill	Change in storage	End of month reservoir storage
		1	2	3	4	5	6	7	8
									146.23
1915	Oct.	30.08	30.61	84.00	20.81	9.27	0	+53.92	200.15
	Nov.	29.14	29.65	57.50	28.24	0.90	0	+28.36	228.51
	Dec.	30.08	30.61	26.30	30.08	0	0	-3.78	224.73
1916	Jan.	30.08	30.61	13.50	29.99	0.09	0	-16.58	208.15
	Feb.	28.14	28.63	7.00	26.99	1.15	0	-21.14	187.01
	Mar.	30.08	30.61	4.00	24.87	5.21	0	-26.08	160.93
	Apr.	29.14	29.65	2.90	25.64	3.50	0	-26.24	134.69
	May	30.08	30.61	2.40	23.83	6.25	0	-27.68	107.01
	June	29.14	29.65	5.00	0	29.14	0	-24.14	82.87
	July	30.08	30.61	13.70	0	30.08	0	-16.38	66.49
	Aug.	30.08	30.61	61.00	0	30.08	0	+30.92	97.41
	Sept.	29.14	29.65	165.50	0	29.14	0	+136.36	233.77
TOTALS		355.26	361.50	442.80	210.45	144.81	0	+87.54	-

1916	Oct.	30.08	30.61	126.50	20.81	9.27	0	+96.42	330.19
	Nov.	29.14	29.65	82.70	28.24	0.90	0	+53.56	383.75
	Dec.	30.08	30.61	39.40	30.08	0	0	+9.32	393.07
1917	Jan.	30.08	30.61	20.20	29.99	0.09	0	-9.88	383.19
	Feb.	27.13	27.61	11.00	26.99	0.14	0	-16.13	367.06
	Mar.	30.08	30.61	6.90	24.87	5.21	0	-23.18	343.88
	Apr.	29.14	29.65	5.00	25.64	3.50	0	-24.14	319.74
	May	30.08	30.61	4.00	23.83	6.25	0	-26.08	293.66
	June	29.14	29.65	6.00	0	29.14	0	-23.14	270.52
	July	30.08	30.61	16.70	0	30.08	0	-13.38	257.14
	Aug.	30.08	30.61	67.00	0	30.08	0	+36.92	294.06
	Sept.	29.14	29.65	149.50	0	29.14	0	+120.36	414.42
TOTALS		354.25	360.42	534.90	210.45	143.80	0	+180.65	-

Sept. 1962

TABLE III-2

COMPUTATION OF FINCHAA FARM DELIVERY REQUIREMENT

	Average monthly data (millimeters)								Total
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	
Consumptive use	98.0	96.0	101.0	100.0	92.0	111.0	111.0	114.0	823.0
Util. rain (80%)	32.0	6.4	5.6	4.8	6.4	32.0	29.6	38.4	155.2
Net C.U.	66.0	89.6	95.4	95.2	85.6	79.0	81.4	75.6	667.8
F.I. efficiency	.7	←					→	.7	.7
Water requirement	94.3	128.0	136.3	136.0	122.3	112.8	116.3	108.0	954.0

Elevation 1450 meters

May 8, 1963

45

TABLE III-3

INFLOW DESIGN FLOOD--FINCHAA DAMSITE--BLUE NILE PROJECT

Time hours	Q cu m per sec	Time hours	Q cu m per sec
0	50.0		
6	305.0	126	277.2
12	612.9	132	268.8
18	951.2	138	260.7
24	1,195.0	144	252.9
30	383.8	150	245.4
36	401.4	156	238.2
42	406.0	162	231.2
48	403.7	168	224.5
54	397.3	174	218.0
60	388.3	180	211.8
66	378.0	186	205.8
72	367.4	192	200.0
78	356.6	198	194.4
84	345.9	204	189.1
90	335.0	210	184.0
96	324.4	216	179.0
102	314.2	222	174.2
108	304.4	228	169.6
114	295.0	234	165.2
120	285.9	240	160.9*

*Discharge may be extended by $K_{6hr} = 0.963$

10-day volume = 279.7 million cu m or 226,800 acre-feet

(See Reclamation Instructions IV 6.6 14C) $Q_t = Q_o K^t$

Q_t = discharge t days after Q_o is measured

K = daily depletion factor

46

TABLE III-4 - FLOOD FREQUENCY AT DAMSITES
FINCHAA AND AMARTI-NESHE PROJECTS

Reservoir	Momentary peak inflow in cu. m./sec. expected to be exceeded once in 5, 10, 25, 50, and 100 years				
	(5)	(10)	(25)	(50)	(100)
Finchaa (Fi-1)	53	53	54	54	54
Amarti (AM-1)	200	230	280	310	340
Neshe (NES-1)	240	290	330	380	410
Amarti-Neshe combined	400	460	530	600	650
Finchaa Diversion					
From frequency curve for record at gage	53	53	54	54	54
Gage to diversion dam = 195 sq. kms.	160	190	220	260	290
Power release	11	11	11	11	11
Total Finchaa Diversion	224	254	285	325	355
Neshe Diversion*	25	32	40	50	55

* Assume Neshe storage dam diverting the Neshe to the Amarti spillway and only the 22.5 square kilometers below it contributing. Add 10 cubic meters per second to each item as power release.

TABLE III-5
RESERVOIR OPERATION STUDY

NESHE AND AMARTI RESERVOIRS--NESHE AND AMARTI RIVERS

RESERVOIR	Min STORAGE (million cu meters)	Max ELEVATION	Max STORAGE (million cu meters)
NESHE	152.9	2,233.98 m	674
AMARTI	12.6	2,233.98	77
Total	165.5 (134,200 ac-ft)		751 (609,000 ac-ft)

FIRM YIELD 310,000,000 cu m per year (251,000 ac-ft) 8,490 hectares served (20,979 acres)

Canal elev. at dam	2,208 m
Canal elev. at tunnel	2,205 m
Jet nozzle elevation	1,625 m
Av. head losses	20 m
Net generator head	560 m
Gen. and turb. eff.	80%

Year	Months	Power generation kw-hr x 10^6	Total inflow to Neshe and Amarti Reservoirs	Total av. surface area m^2 x 10^6	Evaporation and precipitation correction	Power and irrigation release	Spill	Change in storage	End of month reservoir storage	Irrigation demand
		1	2	3	4	5	6	7	8	9
									751	
1911	Oct.	32.9	54	48	0	27	27	0	751	11.44
	Nov.	30.5	8	48	-4	25	0	-21	730	15.52
	Dec.	32.9	0	46	-4	27	0	-31	699	16.53
1912	Jan.	31.7	0	44	-3	26	0	-29	670	16.50
	Feb.	30.5	0	42	-4	25	0	-29	641	14.83
	Mar.	32.9	0	38	-4	27	0	-31	610	13.68
	Apr.	30.5	0	37	-4	25	0	-29	581	14.11
	May	31.7	0	34	-3	26	0	-29	552	13.10
	June	30.5	6	32	+1	25	0	-18	534	0
	July	32.9	20	31	+1	27	0	-6	528	0
	Aug.	31.7	54	32	+1	26	0	+29	557	0
	Sept.	30.5	104	37	0	25	0	+79	636	0
TOTALS		379.2	246		-23	311	27	-115		115.71

1912	Oct.	32.9	42	41	0	27	0	+15	651	11.44
	Nov.	30.5	6	40	-3	25	0	-22	629	15.52
	Dec.		0	38	-3	27	0	-30	599	16.53
1913	Jan.	31.7	0	35	-3	26	0	-29	570	16.50
	Feb.	29.3	0	33	-3	24	0	-27	543	14.83
	Mar.	32.9	0	31	-3	27	0	-30	513	13.68
	Apr.	30.5	0	31	-3	25	0	-28	485	14.11
	May	31.7	0	30	-2	26	0	-28	457	13.10
	June	30.5	4	29	+1	25	0	-20	437	0
	July	32.9	12	29	+1	27	0	-14	423	0
	Aug.	31.7	28	29	+1	26	0	+3	426	0
	Sept.	30.5	54	29	0	25	0	+29	455	0
TOTALS		378.0	146		-17	310	0	181		115.71

Dec. 1962

48

Year	Months	Power generation kw-hr x 10^6	Total inflow to Neshe and Amarti Reservoirs	Total av. surface area m^2 x 10^6	Evaporation and precipitation correction	Power and irrigation release	Spill	Change in storage	End of month reservoir storage	Irrigation demand
		1	2	3	4	5	6	7	8	9
									455	
1913	Oct.	32.9	22	30	0	27	0	-5	450	11.44
	Nov.	30.5	2	29	-2	25	0	-25	425	15.52
	Dec.	32.9	0	28	-2	27	0	-29	396	16.53
1914	Jan.	31.7	0	28	-2	26	0	-28	368	16.50
	Feb.	29.3	0	27	-2	24	0	-26	342	14.83
	Mar.	32.9	0	26	-3	27	0	-30	312	13.68
	Apr.	30.5	0	25	-2	25	0	-27	285	14.11
	May	31.7	0	23	-2	26	0	-28	257	13.10
	June	30.5	10	22	0	25	0	-15	242	0
	July	32.9	30	22	+1	27	0	+4	246	0
	Aug.	31.7	78	23	+1	26	0	+53	299	0
	Sept.	30.5	152	27	0	25	0	+127	426	0
TOTALS		378.0	294		-13	310		-29		115.71

1914	Oct.	32.9	60	29	0	27	0	+33	459	11.44
	Nov.	30.5	8	30	-3	25	0	-20	439	15.52
	Dec.	32.9	0	29	-2	27	0	-29	410	16.53
1915	Jan.	31.7	0	28	-2	26	0	-28	382	16.50
	Feb.	29.3	0	27	-2	24	0	-26	356	14.83
	Mar.	32.9	0	26	-3	27	0	-30	326	13.68
	Apr.	30.5	0	25	-2	25	0	-27	299	14.11
	May	31.7	0	24	-2	26	0	-28	271	13.10
	June	30.5	6	23	+1	25	0	-18	253	0
	July	32.9	20	22	+1	27	0	-6	247	0
	Aug.	31.7	52	23	+1	26	0	+27	274	0
	Sept.	30.5	100	25	0	25	0	+75	349	0
TOTALS		378.0	246		-13	310		-77		115.71

Dec. 1962

49

Year	Months	Power generation kw-hr x 10^6	Total inflow to Neshe and Amarti Reservoirs	Total av. surface area m^2 x 10^6	Evaporation and pre-cipitation correction	Power and irrigation release	Spill	Change in storage	End of month reservoir storage	Irrigation demand
		1	2	3	4	5	6	7	8	9
									349	
1915	Oct.	32.9	40	27	0	27	0	+13	362	11.44
	Nov.	30.5	6	27	-2	25	0	-21	341	15.52
	Dec.	32.9	0	26	-2	27	0	-29	312	16.53
1916	Jan.	31.7	0	25	-2	26	0	-28	284	16.50
	Feb.	30.5	0	23	-2	25	0	-27	257	14.83
	Mar.	32.9	0	22	-2	27	0	-29	228	13.68
	Apr.	30.5	0	21	-2	25	0	-27	201	14.11
	May	31.7	0	19	-1	26	0	-27	174	13.10
	June	30.5	16	18	0	25	0	-9	165	0
	July	32.9	46	19	+1	27	0	+20	185	0
	Aug.	31.7	118	22	+1	26	0	+93	278	0
	Sept.	30.5	228	27	0	25	0	+203	481	0
TOTALS		378.2	454		-11	311		+132		115.71

1916	Oct.	32.9	92	31	0	27	0	+65	546	11.44
	Nov.	30.5	12	32	-3	25	0	-16	530	15.52
	Dec.	32.9	0	31	-3	27	0	-30	500	16.53
1917	Jan.	31.7	0	30	-2	26	0	-28	472	16.50
	Feb.	29.3	0	30	-3	24	0	-27	445	14.83
	Mar.	32.9	0	29	-3	27	0	-30	415	13.68
	Apr.	30.5	0	28	-3	25	0	-28	387	14.11
	May	31.7	0	27	-2	26	0	-28	359	13.10
	June	30.5	18	27	+1	25	0	-6	353	0
	July	32.9	56	27	+1	27	0	+30	383	0
	Aug.	31.7	144	29	+1	26	00	+119	502	0
	Sept.	30.5	278	0	0	25	4	+249	751	0
TOTALS		378.0	600		-16	310	4	+270		115.71

Dec. 1962

50

TABLE III-6

COMBINED AREA-CAPACITY TABLE AFTER 50 YEARS
NESHE-AMARTI RESERVOIR--BLUE NILE PROJECT

Elevation (M)	Area (million sq m)	Capacity (million cu m)	
2234	46.9	731.4	
29	30.5	535.5	
25	28.1	434.7	
20	24.7	325.0	Note: The Amarti portions of the reservoir area and capacity below elevation 2229 (invert of cross channel) are unusable and remain constant at 3.8 million sq m and 8.1 million cu m, respectively, as the reservoir is drawn down below that elevation.
15	20.7	231.7	
10	16.8	155.6	
5	13.4	98.7	
2200	10.4	57.6	
95	7.8	29.7	
90	5.8	14.5	
85	4.2	8.3	
83.6	3.8	8.1	

Sept. 26, 1963

TABLE III-6

50-YR. SEDIMENT DISTRIBUTION--AMARTI RESERVOIR (WITHOUT NESHE)--BLUE NILE PROJECT

Area Increment Method

Elevation (M)	Original area (million sq m)	Original capacity (million cu m)	Ao (million sq m)	Sediment volume (million cu m)	50-year revised	
					Area (million sq m)	Capacity (million cu m)
2234	18.7	77.3	1.2	10.5	17.5	66.8
33	16.5	60.6	1.2	9.3	15.3	51.3
32	13.8	45.0	1.2	8.1	12.6	36.9
31	10.7	29.5	1.2	6.9	9.5	22.6
30	7.6	19.0	1.2	5.7	6.4	13.3
29	5.0	12.6	1.2	4.5	3.8	8.1
28	4.0	7.7	1.2	3.3	2.8	4.4
27	3.0	3.9	1.2	2.1	1.8	1.8
26	2.0	1.1	1.2	0.9	0.8	0.2
25.6	1.2	0.4	1.2	0.4	0	0
25	0	0	0	0	0	0

Sept. 26, 1963

52

TABLE III-6

50 AND 100-YR. SEDIMENT AT DAM--AMARTI RESERVOIR--BLUE NILE PROJECT

Type III Reservoir

S = 10.5 million cu m (50 yrs.) 21.0 million cu m (100 yrs.)

Assume maximum normal water surface at elevation 2234, then H = 9

Elevation	p	V(pH)	S-V(pH)	HA(pH)	h'p
			50 yrs.		
2225.5	0.056	0.3	10.2	9.0	1.133
2226	0.111	1.1	9.4	18.0	0.522
2227	0.222	3.9	6.6	27.0	0.244
2225.25	0.0278	0.1	10.4	4.5	2.31
			100 yrs.		
2225.5	0.056	0.3	20.7	9.0	2.30
2226	0.111	1.1	19.9	18.0	1.106
2227	0.222	3.9	17.1	27.0	0.633
2227.5	0.278	5.7	15.3	31.5	0.486
2228	0.333	7.7	13.3	36.0	0.370
2229	0.444	12.6	8.4	45.0	0.187

Sept. 26, 1963

TABLE III-6

50-YR. SEDIMENT DISTRIBUTION--NESHE RESERVOIR (WITHOUT AMARTI)--BLUE NILE PROJECT

Area Increment Method

Elevation (M)	Original area (million sq m)	Original capacity (million cu m)	Ao (million sq m)	Sediment volume (million cu m)	50-year revised	
					Area (million sq m)	Capacity (million cu m)
Flood pool				10.5		
2234	29.6	674.8	0.2	10.2	29.4	664.6
29	26.9	536.6	0.2	9.2	26.7	527.4
25	24.5	435.0	0.2	8.4	24.3	426.6
20	21.1	324.3	0.2	7.4	20.9	316.9
15	17.1	230.0	0.2	6.4	16.9	223.6
10	13.2	152.9	0.2	5.4	13.0	147.5
05	9.8	95.0	0.2	4.4	9.6	90.6
2200	6.8	52.9	0.2	3.4	6.6	49.5
95	4.2	24.0	0.2	2.4	4.0	21.6
90	2.2	7.8	0.2	1.4	2.0	6.4
85	0.6	0.6	0.2	0.4	0.4	0.2
83.6	0.2	0.1	0.2	0.1	0	0
83	0	0	0	0	0	0

Sept. 26, 1963

54

TABLE III-6

50 AND 100 YR. SEDIMENT AT DAM--NESHE RESERVOIR--BLUE NILE PROJECT

Type III Reservoir

S = 10.5 million cu m (50 yrs.) 21.0 million cu m (100 yrs.)

Assume maximum normal water surface at elevation 2234, then H = 51

Elevation	p	V(pH)	S-V(pH)	HA(pH)	h'p
			50 yrs.		
2183.5	0.0098	0.04	10.46	8.16	1.28
2184	0.0196	0.2	10.3	16.3	0.632
2185	0.0392	0.6	9.9	32.6	0.304
2186	0.0588	1.4	9.1	49.0	0.186
			100 yrs.		
2184	0.0196	0.2	20.8	16.3	1.276
2185	0.0392	0.6	20.4	32.6	0.626
2186	0.0588	1.4	19.6	49.0	0.400

September 26, 1963

50

At 80 percent turbo-generator efficiency, the operation study shows that the plant can operate under a level load curve (i.e., with approximately the same average kilowatts of generation each month) with an annual generation of 378 million kilowatt-hours, while also serving the irrigation project.

Irrigated Area

Estimated farm delivery requirement for the Amarti-Neshe Project area is 0.954 meter (3.13 feet). This estimate is the same as for the Finchaa Project of similar elevation and location, shown in Table III-2. Allowing 10 percent for canal seepage and 20 percent for operational waste, the operation study shows that, if the reservoir is constructed and operated in accordance with the proposal, much more than 8,490 hectares (20,970 acres) could be irrigated with no shortages.

Spillway Design Flood

Table III-7 shows ordinates of the estimated maximum probable reservoir inflow flood from the two drainage basins. Table III-8 shows ordinates of the maximum probable flood that could come down the Neshe and would have to be passed through the cross channel to be spilled at Amarti dam.

Flood Frequency

Table III-4 shows frequency of floods expected to be encountered during construction at each of the damsites.

Outlet Capacity

In order to provide for peak operation of the Neshe plant at twice the average release (during months of low content), the outlet from Neshe reservoir to the power canal will require a capacity of 20 cubic meters per second (706 cubic feet per second) when water surface is at the minimum operating level of 2229 meters.

56

TABLE III-7

MAXIMUM PROBABLE FLOOD - NESHE-AMARTI (COMBINED)
BLUE NILE PROJECT

$T_p = 0.749$ $\qquad \frac{ad}{q_p} = \frac{554 \times 10^6 \times 0.195}{1,910} \times 0.749 = 42,400$

a = drainage area in sq meters = 554×10^6

d = depth of runoff in meters = 0.195

q_p = flood peak in cu m per sec = 1,910

Basic ratios T/T_p	Basic ratios q/q_p	Time in thousand sec.	Design flood in cu m per sec: Hydrograph	Base flow a/	Total	Subtotal	Million cu m
0	0	0	0	29	29		
0.1	0.015	4	29	29	58		
0.2	0.075	8	143	29	172		
0.3	0.16	13	306	29	335		
0.4	0.28	17	535	29	564		
0.5	0.43	21	821	29	850		
0.6	0.60	25	1,146	29	1,175		
0.7	0.77	30	1,471	29	1,500		
0.8	0.89	34	1,700	29	1,729		
0.9	0.97	38	1,853	29	1,882		
1.0	1.00	42	1,910	29	1,939		
1.1	0.98	47	1,872	29	1,901		
1.2	0.92	51	1,757	29	1,786		
1.3	0.84	55	1,604	29	1,633		
1.4	0.75	59	1,432	29	1,461		
1.5	0.66	64	1,261	29	1,290		
1.6	0.56	68	1,070	29	1,099	18,839	80.07
1.8	0.42	76	802	29	831		
2.0	0.32	85	611	29	640		
2.2	0.24	93	458	29	487		
2.4	0.18	102	344	29	373		
2.6	0.13	110	248	29	277		
2.8	0.098	119	187	29	216		
3.0	0.075	127	143	29	172	3,460	29.15
3.5	0.036	148	69	29	98		
4.0	0.018	170	34	29	63		
4.5	0.009	191	17	29	46		
5.0	0.004	212	8	29	37	311	6.61
Days		2.45					115.83
		say 2-1/2 days					say 116

Time scale: $\frac{68}{16} = 4.25$; $\frac{59}{7} = 8.428$; $\frac{85}{4} = 21.25$

Subtotal: $\left(\frac{29+1,099}{2} + 18,275\right)$; $\left(\frac{1,099+172+2,824}{2}\right)$; $\left(\frac{172+37+207}{2}\right)$

a/ August (1932) av. = 78 million cu m $\qquad$ 2,673,400 = 29 cu m per sec

Sept. 1963

TABLE III-8

MAXIMUM PROBABLE FLOOD - NESHE (WITHOUT AMARTI)
BLUE NILE PROJECT

$$T_p = 0.749 \qquad \frac{ad}{q_p} = 0.749 \frac{309 \times 10^6 \times 0.207}{1,240} = 38,650$$

a = drainage area in sq meters = 309×10^6

d = depth of runoff in meters = 0.207

q_p = flood peak in cu m per sec = 1,240

Basic ratios		Time in thousand sec.	Design flood in cu m per sec		
T/T_p	q/q_p		Hydro-graph	Base flow a/	Total
0	0	0	0	15	15
0.1	0.015	4	19	15	34
0.2	0.075	8	93	15	108
0.3	0.16	12	198	15	213
0.4	0.28	15	347	15	362
0.5	0.43	19	533	15	548
0.6	0.60	23	744	15	759
0.7	0.77	27	955	15	970
0.8	0.89	31	1,104	15	1,119
0.9	0.97	35	1,203	15	1,218
1.0	1.00	39	1,240	15	1,255
1.1	0.98	42	1,215	15	1,230
1.2	0.92	46	1,141	15	1,156
1.3	0.84	50	1,042	15	1,057
1.4	0.75	54	930	15	945
1.5	0.66	58	818	15	833
1.6	0.56	62	694	15	709
1.8	0.42	70	521	15	536
2.0	0.32	77	397	15	412
2.2	0.24	85	298	15	313
2.4	0.18	93	223	15	238
2.6	0.13	101	161	15	176
2.8	0.098	108	122	15	137
3.0	0.075	116	93	15	108
3.5	0.036	135	45	15	60
4.0	0.018	155	22	15	37
4.5	0.009	174	11	15	26
5.0	0.004	193	5	15	20

a/August (1932) av. = 39 million cu m 2,678,400 = 15 cu m per sec.

Sept. 1963

58

SECTION IV - GEOLOGY

General Geology of the Area

The headwaters of the Finchaa drainage system originate from high volcanic mountains, composed mostly of basalt, which have been eroded into sharp, steep ridges and valleys. Volcanic plugs, ranging from dark colored basalt to light colored rhyolite, are common physiographic features in this mountainous area.

Northward, at lower elevations the volcanic material feathers out on the wide, flat rolling plateau. In this northward or downstream direction, due to erosion and probably to the thinning of the volcanic lava flows, the streams have cut through the volcanic materials into flat-lying, massive beds of adigrat sandstone, which constitute the principal rocks forming the lower part of the plateau.

In the vicinity of the outlet of the swamp, the ridges are composed of sandstone, but in the valley or canyon the Finchaa River is flowing on an intervalley flow of basalt which was deposited within an older, previously eroded valley. It is believed that the intervalley filling of lava is younger than the "plateau" volcanics and probably originated in the vicinity of the volcanic plugs and cones upstream within the swamp area. It is this intervalley filling of volcanic rock, which is harder than the sandstone, which is responsible for the vertical waterfalls. It has also retarded erosion and entrenchment of the streams in the swamp, resulting in the large, flat, poorly drained, land area on the high plateau. It is on the intervalley volcanic rock in the canyon below the outlet of the swamp that dams and other engineering structures will be constructed to develop the project.

The intervalley volcanic rock is hard and jointed, but it is not extremely porous like most other younger volcanic rock in the Blue Nile River Basin. Apparently it was deposited as a thick, massive flow, whereas most other younger volcanics were deposited in intermittent, thin flows that became scoriaceous and badly broken.

Geologic Reconnaissance

Drawing No. 5.2-Fi-2, Finchaa and Amarti-Neshe areas, covers the general geology in the project areas and at the structure sites. The map was constructed by tracing aerial photographs, after making field inspections on the ground and from helicopter flights. Auger holes were drilled to obtain samples of construction materials and they were analyzed by the Imperial Ethiopian Highway Authority Laboratory.

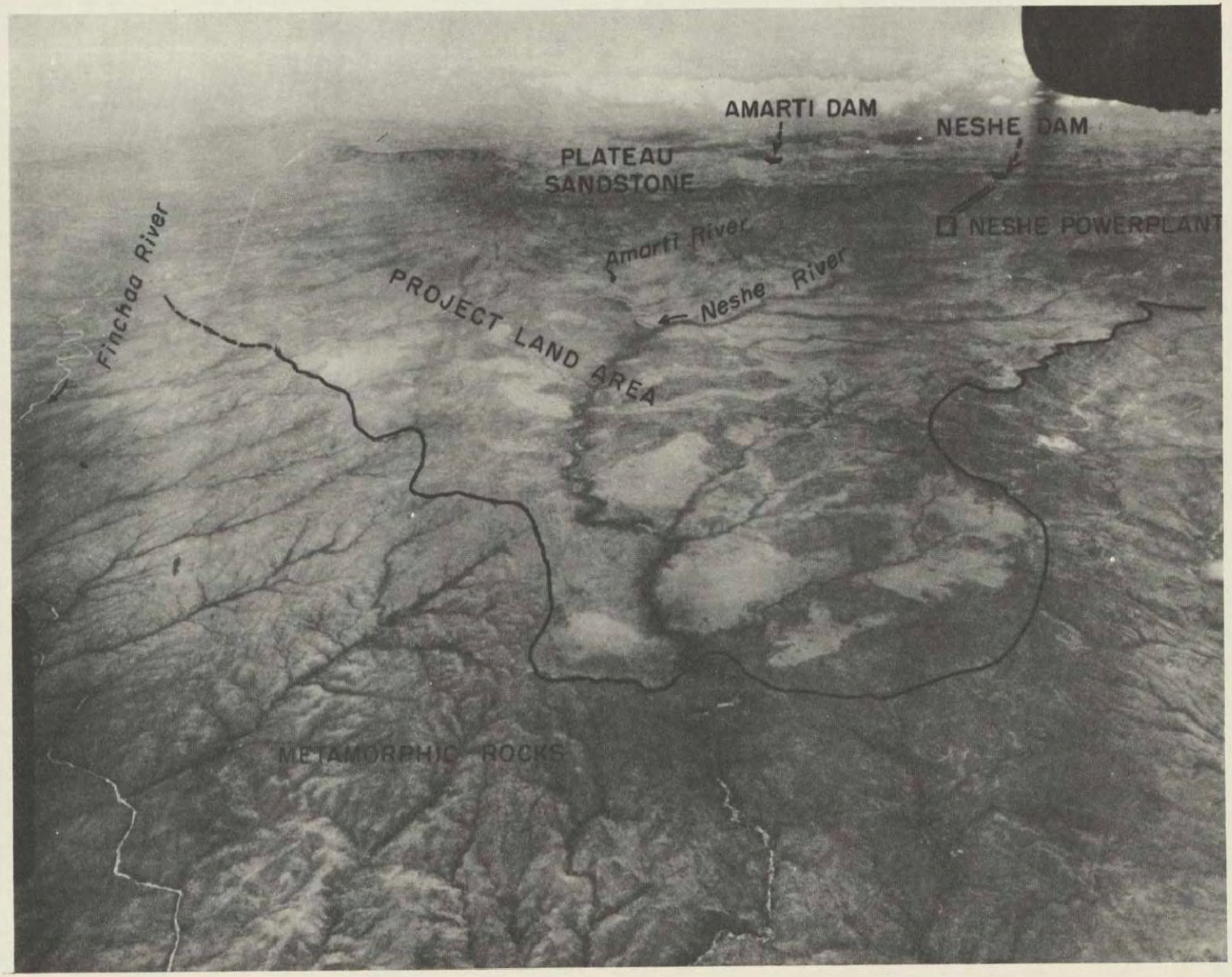
Seismology

The country of Ethiopia is considered to be in an active seismic area due to the close association with the great rift system passing through Ethiopia. The Ethiopian plateau, of which the Blue Nile River Basin is a part, has been vertically uplifted many hundreds of meters, but it is remarkable that little disturbance or tectonic movements have occurred within the plateau area.

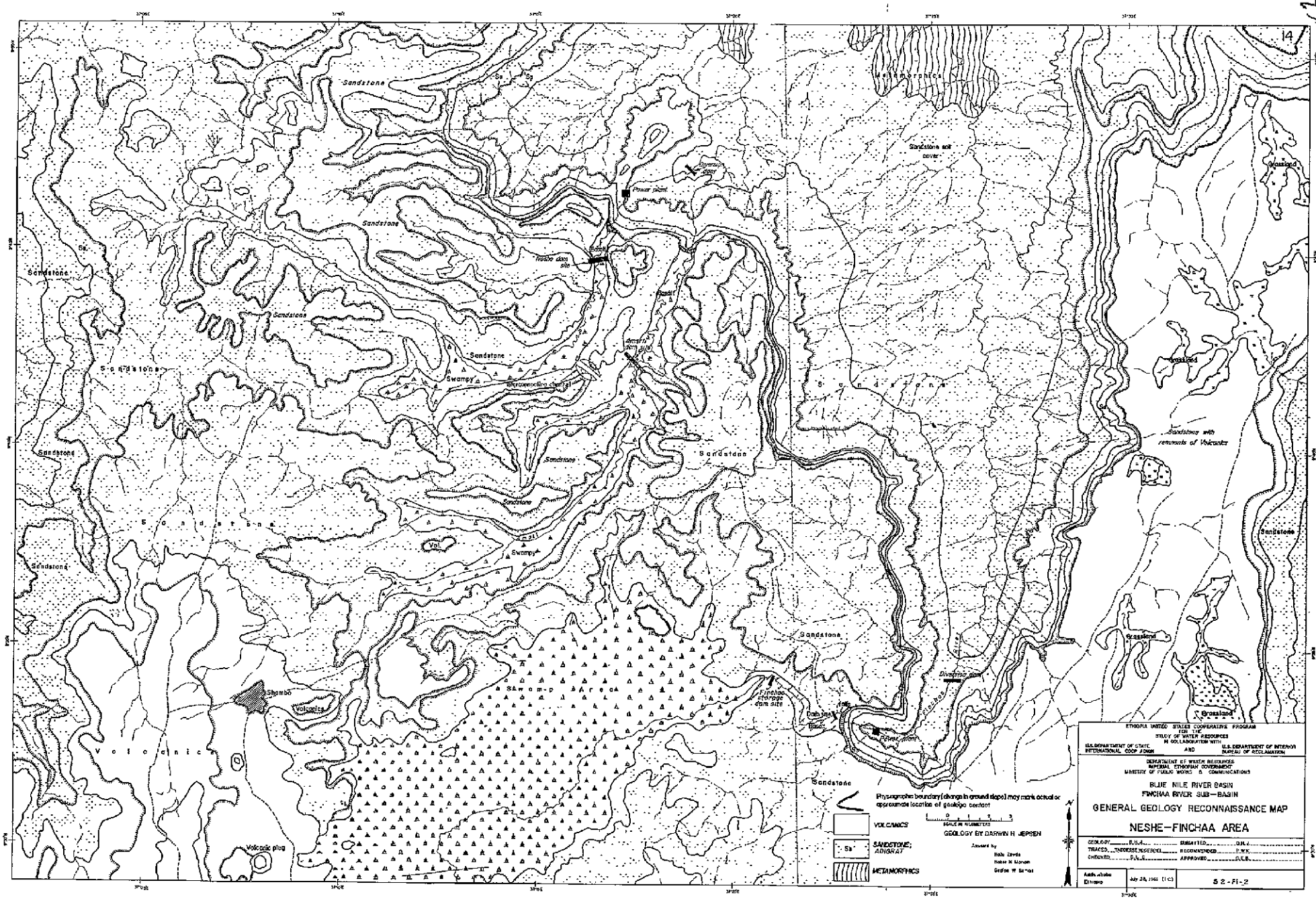
No active faults are known to exist within close proximity to the Finchaa and Amarti-Neshe project area, and certainly not within the structure locations. While structures should be designed with margins of safety to withstand intensive earthquake shocks, no serious problems of a seismic nature are anticipated.

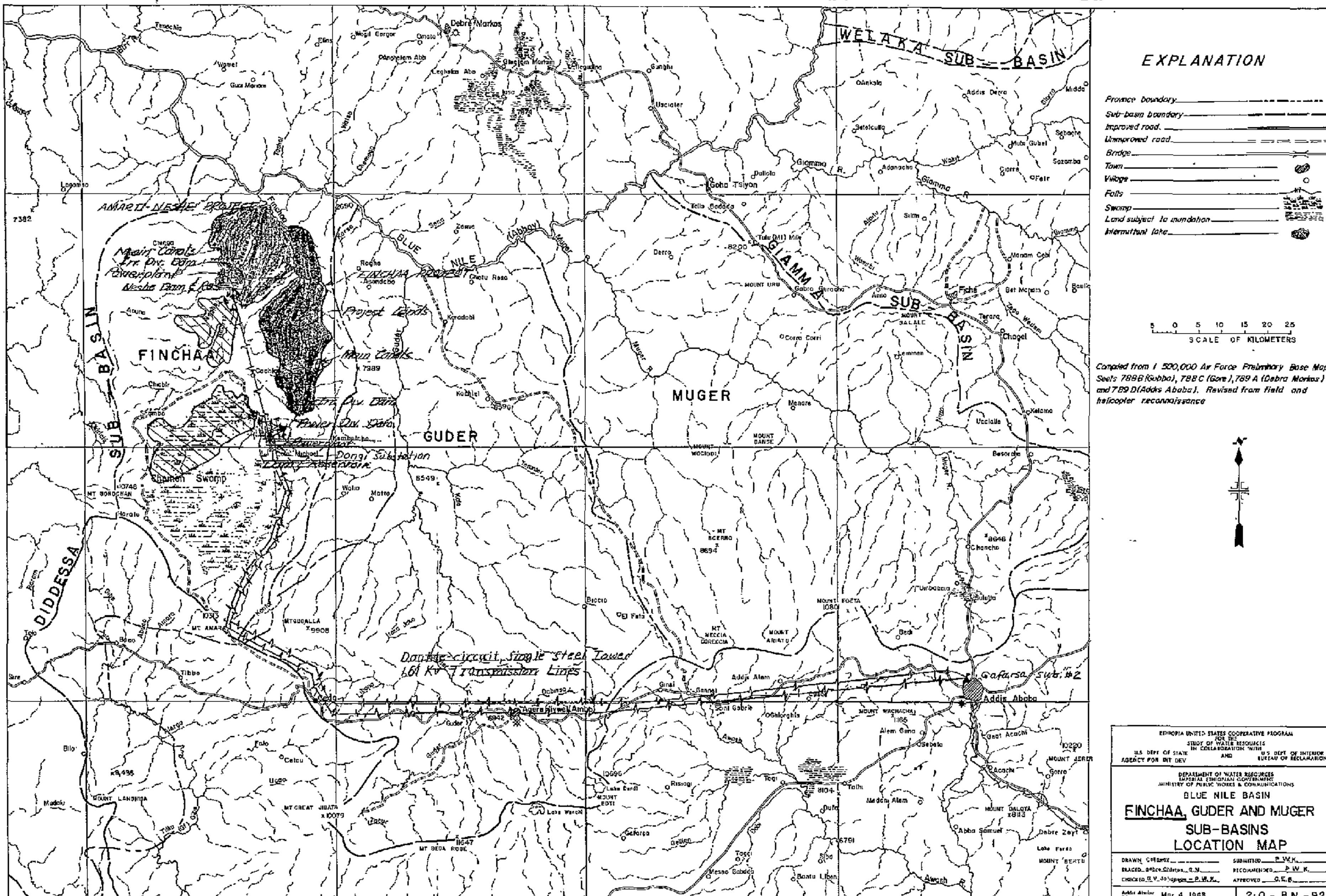
Ground Water

The Finchaa and Amarti-Neshe project areas are on well drained slopes underlain by sandstone. Sources of groundwater supplies for irrigation are not available. The relief and good drainage slopes do not suggest that salt accumulations and water-logging of lands will readily develop in the project areas if irrigation water is properly applied.



AMARTI-NESHE PROJECT (View Upstream)


14
Sandstone
Sandstone soil cover
Metamorphics
Power plant
Diversion dam
Neshe dam site
Amarti dam site
Swampy
Marsh
Grassland
Sandstone with remnants of Volcanics
Volcanics
Shambo
Volcanic plug
Swamp Area
Finchaa storage dam site
Finchaa River
Diversion dam
Dabana
Physiographic boundary (change in ground slope) may mark actual or approximate location of geologic contact
VOLCANICS
SANDSTONE; ADIGRAT
METAMORPHICS
SCALE IN KILOMETERS
GEOLOGY BY DARWIN H. JEPSEN
Assisted by
Haile Zewde
Habte M. Mariam
Gedion W. Semai
ETHIOPIA UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH
U.S. DEPARTMENT OF STATE INTERNATIONAL COOP. ADMIN.
AND
U.S. DEPARTMENT OF INTERIOR BUREAU OF RECLAMATION
DEPARTMENT OF WATER RESOURCES IMPERIAL ETHIOPIAN GOVERNMENT MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN
FINCHAA RIVER SUB-BASIN
GENERAL GEOLOGY RECONNAISSANCE MAP
NESHE-FINCHAA AREA
GEOLOGY D.H.J. SUBMITTED D.H.J.
TRACED TADESSE NEGERCHI RECOMMENDED P.W.K.
CHECKED D.H.J. APPROVED D.E.B.
Addis Ababa Ethiopia
July 28, 1961 (1:C)
S2-Fi-2


EXPLANATION
Province boundary
Sub-basin boundary
Improved road
Unimproved road
Bridge
Town
Village
Falls
Swamp
Land subject to inundation
Intermittent lake
SCALE OF KILOMETERS
Compiled from 1:500,000 Air Force Preliminary Base Maps Seets 788 B (Gubba), 788 C (Gore), 789 A (Debra Markos) and 789 D (Addis Ababa). Revised from field and helicopter reconnaissance
WELAKA SUB-BASIN
GIAMMA SUB-BASIN
FINCHAA SUB-BASIN
DIDDESSA SUB-BASIN
FINCHAA
GUDER
MUGER
BLUE NILE (Abbay)
AMARTI-NESHE PROJECT
FINCHAA PROJECT
Project Lands
Main Canals
Double-circuit, Single Steel Tower 161 KV Transmission Lines
Gafarsa Sub. #2
Addis Ababa
Debre Markos
Chomen Swamp
ETHIOPIA UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH
U.S. DEPT OF STATE AGENCY FOR INT DEV AND U.S. DEPT OF INTERIOR BUREAU OF RECLAMATION
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE BASIN
FINCHAA, GUDER AND MUGER
SUB-BASINS
LOCATION MAP
SUBMITTED P.W.K.
RECOMMENDED P.W.K.
APPROVED C.E.B.
Addis Ababa Ethiopia
Mar 4, 1968
2-0-BN-92

SECTION V - PLANS AND ESTIMATES

Comprehensive Plan of Development

The comprehensive development of the Finchaa Sub-Basin (Dwg. No. 2.0-BN-92) would extend over a long period of years and includes the construction of three storage dams, two irrigation diversion dams, one power diversion dam, one power canal, two pressure tunnels, penstocks, two hydroelectric powerplants, main canals, distribution systems, and drainage canals. The plan envisions the development of approximately 23,500 hectares of land for irrigation and generation of 160,000 kilowatts of hydroelectric power.

The development plan for the Finchaa Sub-Basin is divided into two broad plans--the Finchaa Project and the Amarti-Neshe Project. Both projects would be essentially similar in scope and purpose--the development of the land and water resources for irrigation and hydroelectric power production. The Finchaa Project appears to be the more economically attractive of the two because of its initial low investment, primarily due to the low cost in utilizing Chomen Swamp for storage.

FINCHAA PROJECT

Plan of Development

The multipurpose development plan includes a storage dam, a power diversion dam, a power tunnel and penstocks, a powerplant, transmission facilities, an irrigation diversion dam, two main canals (one on each side of the river), and a distribution system and surface drains to provide irrigation for 15,000 hectares of land and 80,000 kilowatts of power installation.

Storage would be provided by the potential Finchaa Reservoir, made possible by constructing a low dam at the outlet of Chomen Swamp. From this storage, a continuous discharge would be made into the Finchaa River channel whence the flow would be diverted about five kilometers downstream by means of a diversion dam through a tunnel and penstocks for production of hydroelectric power. The

discharge from the powerplant would be made into the river channel below the escarpment and again diverted by another diversion dam into the two main canals to convey the water for irrigation purposes. These canals would roughly parallel the river, the canal on the east side being 56.7 kilometers in length and the one on the west side being 43.1 kilometers in length.

Project Features

The features of the multipurpose project plan are shown in general on Drawing No. 2.0-Fi-2 and are described in reconnaissance detail in the following paragraphs. Topography of the project area (Dwg. No. 2.0-Fi-9) was compiled from stereoscopic projection (multiplex) to a scale of 1:20,000 with 20-meter contour intervals. Controls for the multiplex compilation consisted of (1) horizontal distances measured with tellurometer, third order, and (2) vertical control by trigonometric leveling, using in both cases first order triangulation stations established by the U. S. Coast and Geodetic Survey. Profile of the river is shown in Drawing No. 4.0-BN-74.

Finchaa Dam and Reservoir

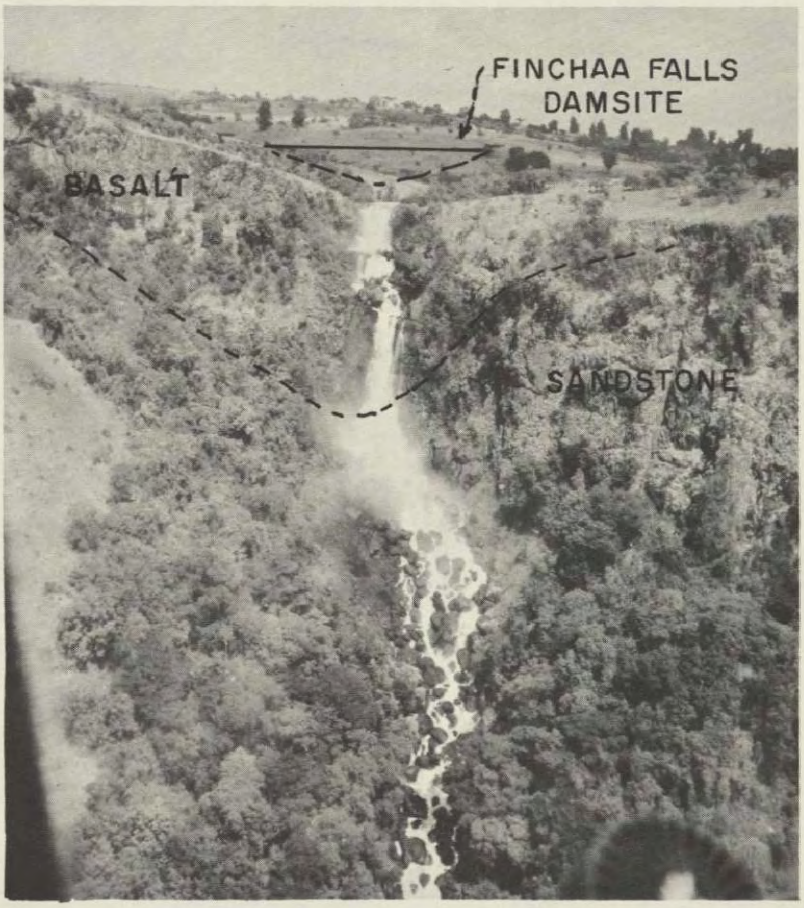
Finchaa Dam. The proposed damsite would be near the outlet of the Chomen Swamp about five kilometers upstream from the Finchaa Falls. It would be a concrete-masonry dam with an ogee-type spillway at the center section. Diversion during construction would be accomplished by gap in the dam, the gap to be closed during the dry season and the floods routed through the completed outlet and spillway section. See Drawing No. OA-23-101 for plan, profile, and section of dam.

Finchaa Dam Data

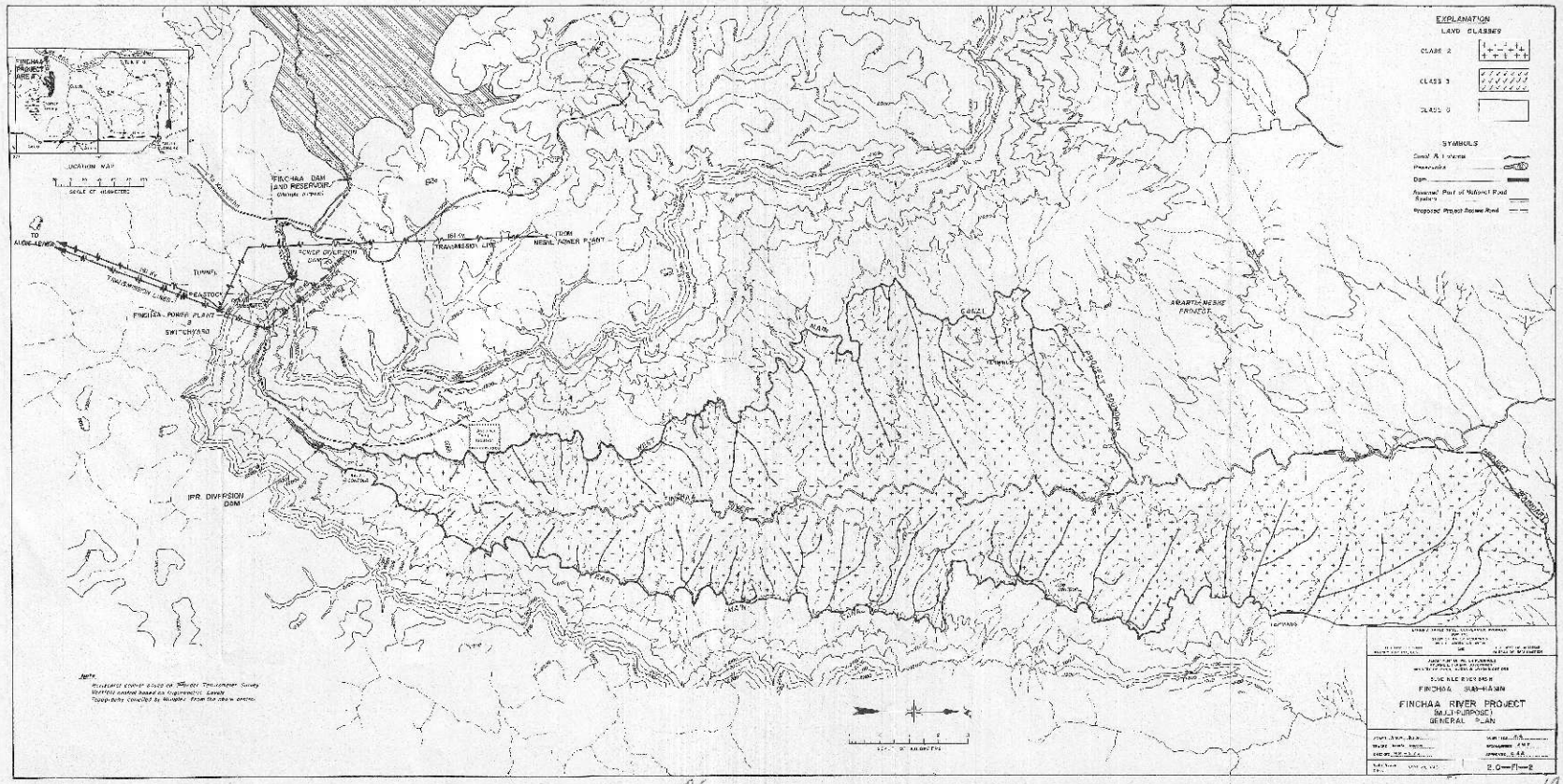
Type	masonry-ogee
Volume of concrete and masonry in dam	3,800 cu.m.
Elevation of spillway crest	2213.40 m.
Structural height	8.00 m.
Hydraulic height	7.23 m.
Length of crest	210 m.

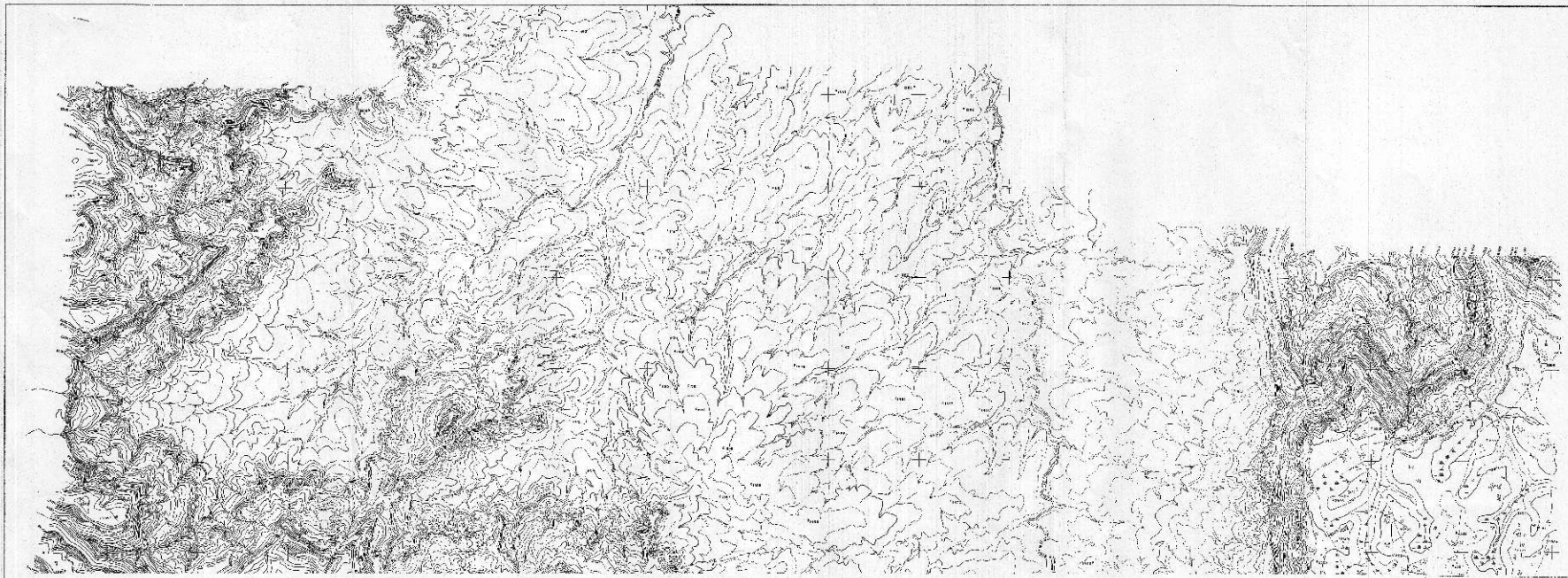
Spillway. The design of the spillway was based on an inflow design flood showing a peak inflow of 1,195 cubic meters per second and a 10-day volume of 280 million cubic meters. In routing the flood it was assumed that the reservoir would be at normal water surface elevation 2213.40 meters at the beginning of the flood. The spillway would discharge 70 cubic meters per second at maximum water surface elevation 2214.23 meters.

FINCHAA DAMSITE FI-I — LOOKING DOWNSTREAM



FINCHAA FALLS FI-2 FOREBAY DAMSITE


EXPLANATION
LAND CLASSIFICATION
CLASS 2
CLASS 3
CLASS 0
SYMBOLS
Canal & Laterals
Pipelines
Dam
Reserved Part of National Road System
Proposed Project Access Road
LOCATION MAP
SCALE OF MILES
FINCHAA DAM AND RESERVOIR
TO ALDER-LAKE
TUNNEL
PENSTOCK
FINCHAA POWER PLANT & SWITCHYARD
TRANSMISSION LINES
LOWER DIVERSION DAM
TRANSMISSION LINE
FROM NEBIL POWER PLANT
CANAL
ARAPTH-NESKE PROJECT
IPR DIVERSION DAM
FINCHAA
MAIN
Note:
Boundaries shown based on Topo. Transmission Survey
Roads shown based on topographic survey
Topography compiled by Hunter from the above sources.
FINCHAA SUB-BASIN
FINCHAA RIVER PROJECT
(MULTI-PURPOSE)
GENERAL PLAN



MATCH TO SHEET 2

NOTES:

1. Horizontal control based on 5th order triangulation survey. Vertical control based on trigonometric levels. Topography computed by multiplex from the above control.
2. Contour interval 20 metres.

FINCHAA RIVER AREA
TOPOGRAPHY

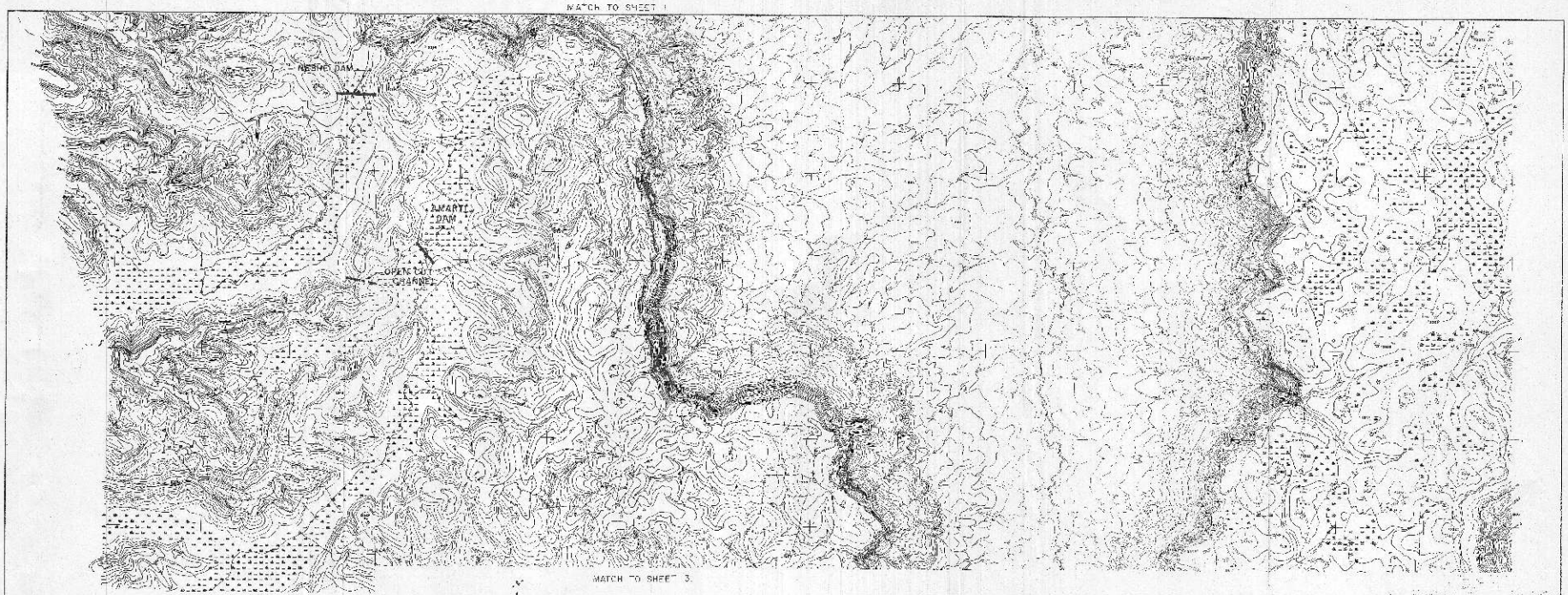
G.V.J. — A.P.B.
N.M. — P.W.K.
G.V.J. — G.E.B.

SHEET 1 OF 3

70

70B

MATCH TO SHEET 1



MATCH TO SHEET 3.

N

NOTES:

FINCHAA RIVER AREA
TOPOGRAPHY

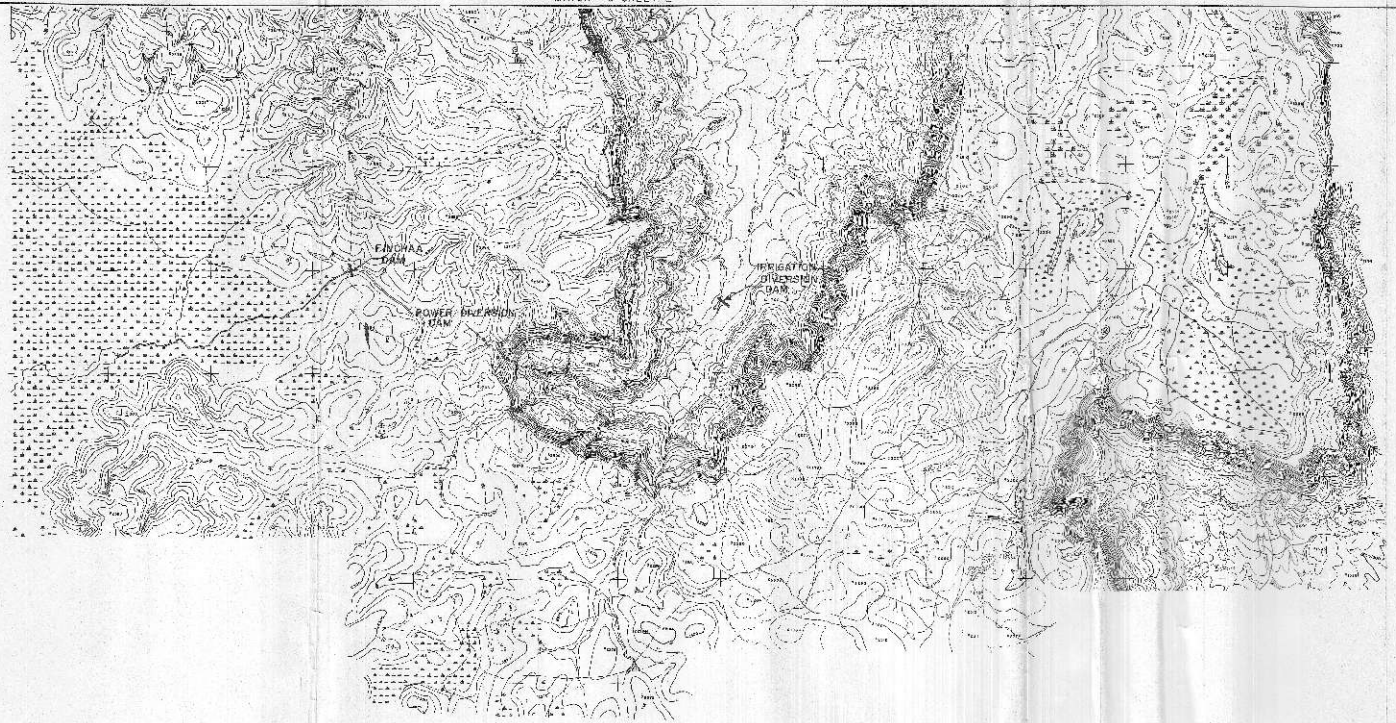
SHEET 2 OF 3.

71

71A

71B

MATCH TO SHEET 2



NOTES:

1. Horizontal control based on 3° Gauss Krüger Survey. Vertical control based on Hydrographic levels. Topography compiled by Multiplex from the above control.
2. Contour interval 20 meters.

SCALE OF 10 METRES

FINCHAA RIVER AREA
TOPOGRAPHY

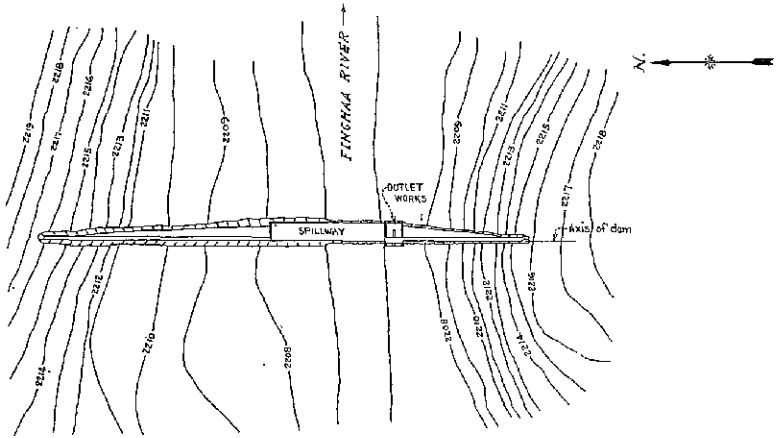
2.0—Fi—9

SHEET 3 OF 3.

12

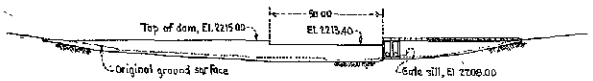
121

122

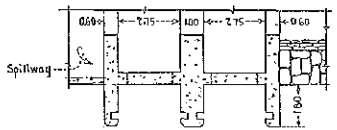


PLAN - FINCHAA STORAGE DAM

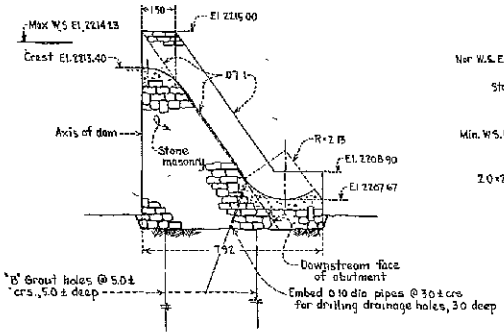
SCALE OF METERS



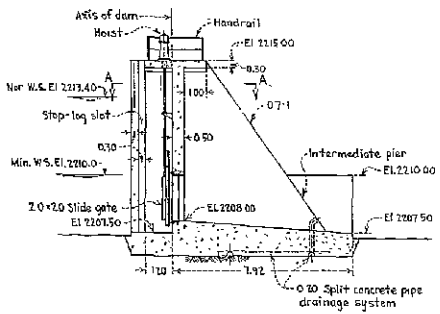
UPSTREAM ELEVATION



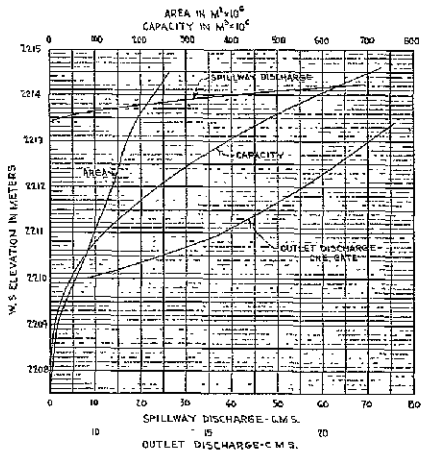
SECTION A-A



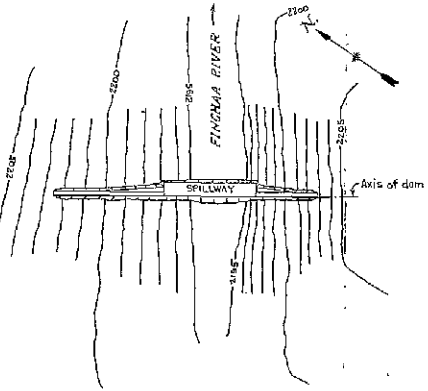
TYPICAL SPILLWAY SECTION



SECTION THRU OUTLET WORKS

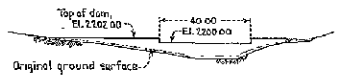


AREA - CAPACITY - DISCHARGE CURVES
FINCHAA STORAGE DAM

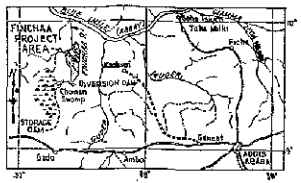


PLAN - FINCHAA POWER DIVERSION DAM

SCALE OF METERS

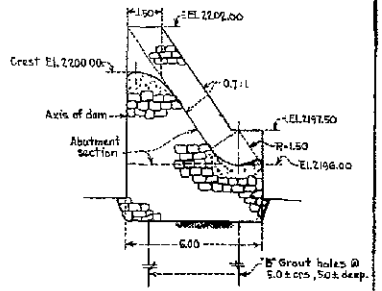


UPSTREAM ELEVATION



LOCATION MAP

SCALE OF KILOMETERS



TYPICAL SPILLWAY SECTION
POWER DIVERSION DAM

NOTES

All dimensions are in meters.
Reinforcement required for storage dam outlet works.
The power diversion dam is located approximately 5 kilometers downstream from the storage dam.

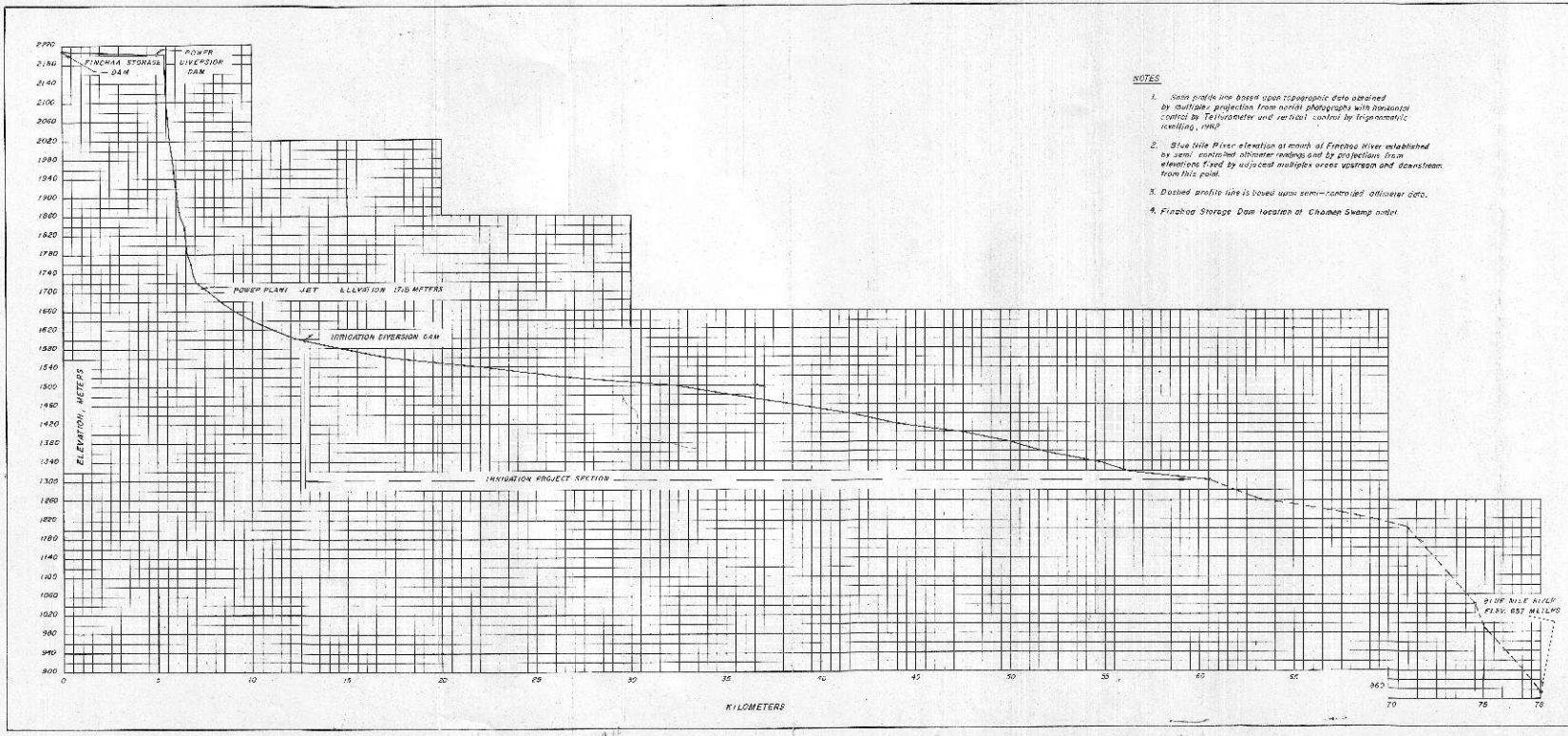
ETHIOPIA - UNITED STATES COOPERATIVE PROGRAM
FOR THE
STUDY OF WATER RESOURCES
IN COOPERATION WITH
U.S. DEPT. OF STATE AGENCY FOR INT. DEV. AND U.S. DEPT. OF INTERIOR BUREAU OF RECLAMATION

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

FINCHAA STORAGE DAM
AND
FINCHAA POWER DIVERSION DAM

DENVER, COLORADO. NOV 8, 1955. OA-23-101.



NOTES

1. Main profile are based upon topographic data obtained by multiplex projection from aerial photographs with horizontal control by Tellurometer and vertical control by trigonometric levelling, 1962.

2. Blue Nile River elevation at mouth of Finchaa River established by semi controlled altimeter readings and by projections from elevations fixed by adjacent multiplex areas upstream and downstream from this point.

3. Dotted profile line is based upon semi-controlled altimeter data.

4. Finchaa Storage Dam location at Chomen Swamp outlet

BLUE NILE RIVER BASIN

PROFILE FINCHAA RIVER

CHOMEN SWAMP OUTLET TO MOUTH

DRAWN: R.V.W.S.E. SUPERVISED: E.G.&E.
CHECKED: R.W.K. RECOMPUTED: R.W.K.
APPROVED: R.E.K. DRAWING: C.S.-2.

DATE: OCT. 1, 1962 | 4 5-24-74

746

Spillway Data

Spillway crest elevation	2213.40 m.
Inflow design flood	1,195 cu. m. per sec.
Total flood volume, 10 days	280 million cu. m.
Discharge at maximum w.s. elevation	70 cu. m. per sec.

Outlet Works. The outlet works would be located on the right abutment of the dam and would consist of two, 2.0- x 2.0-meter, slide gates with a capacity of 16 cubic meters per second at minimum water surface elevation of 2210. Stop logs have been provided for closure of the gates if required in case of emergencies or repairs to the slide gates.

Outlet Works Data

Sill elevation	2208 m.
Discharge capacity (each)--n.w.s.	23 cu. m. per sec.
Type of gate	2- x 2-m. slide gates

Reservoir. The Finchaa Reservoir would be in the Chomen Swamp, the basin of which is covered with black clay of unknown depth. It may be as much as 10 meters in depth and is believed to be underlain by volcanic rock. This soil cover forms an excellent impermeable blanket, and seepage is not considered to be a serious factor. The reservoir at normal water surface elevation would impound 464 million cubic meters of water at initial storage, covering an area of 188 square kilometers. Reservoir data are shown on Drawing No. 2.2-BN-1, and the area-capacity curve is shown on Drawing No. 2.0-Fi-1 (see SECTION III), including sediment disposition.

Site Geology

Finchaa Storage Dam. Geology at the damsites studied within the Finchaa canyon between the falls and the outlet of the swamp indicates that the foundation rock is of hard basalt which is exposed along the stream channel and generally on the sides of the valley. The soil mantle is relatively thin, perhaps up to two meters thick in local areas. The volcanic bedrock is jointed but believed to be groutable to the point that excessive leakage from the reservoir and beneath the dam can be prevented. Inasmuch as a relatively low dam will provide abundant storage and regulation, leakage is not considered to be a serious problem; however, a grout curtain under the dam at this storage site should be included in the design and cost estimates. Core trench excavation depth will average about two meters. A geologic section is shown on Drawing No. 4.0-Fi-5.

Finchaa Power Diversion Dam. Since bedrock materials are exposed at the site, required cutoff trench excavations in the stream channel and on parts of the abutments should not exceed an average depth of two meters to remove loose rock, mud seams, tree roots, and other nongroutable material along the cutoff core of the dam. Only in local areas will stripping be required to remove vegetation, such as roots of brush and large trees in the dam foundation area. A concrete or masonry-rock structure is recommended at this location. A geologic section is shown on Drawing No. 4.0-Fi-9.

Powerplant Site. The penstock tunnel will penetrate basaltic lava rock from the intake to the approximate base of the lower vertical waterfall, at which point the excavation will continue in friable sandstone to the powerplant location, where there are thick accumulations of talus, large boulders, and soil cover, probably up to 7.5 meters in depth. Beneath the talus debris the foundation for the powerplant is sandstone.

Irrigation Diversion Damsite. The irrigation diversion damsite is located below the plateau downstream from the powerplant. The foundation for the dam will be Adigrat sandstone. Canals will be common excavation in deep residual and slopewash soils over sandstone bedrock.

Construction Materials

There is abundant, good, sandy clay for impervious earth materials near the damsite. These materials are deep, residual soils, weathered from sandstone, and cover the gently rolling ridges and slopes adjacent to the damsite. No natural concrete aggregates nor pervious alluvial embankment materials were observed, and it is doubtful that any exist within an economical haul distance of the damsite. However, the hard, volcanic rock adjacent to the damsite can be quarried for rockfill, riprap, or masonry and can be crushed for concrete or mortar aggregate.

76

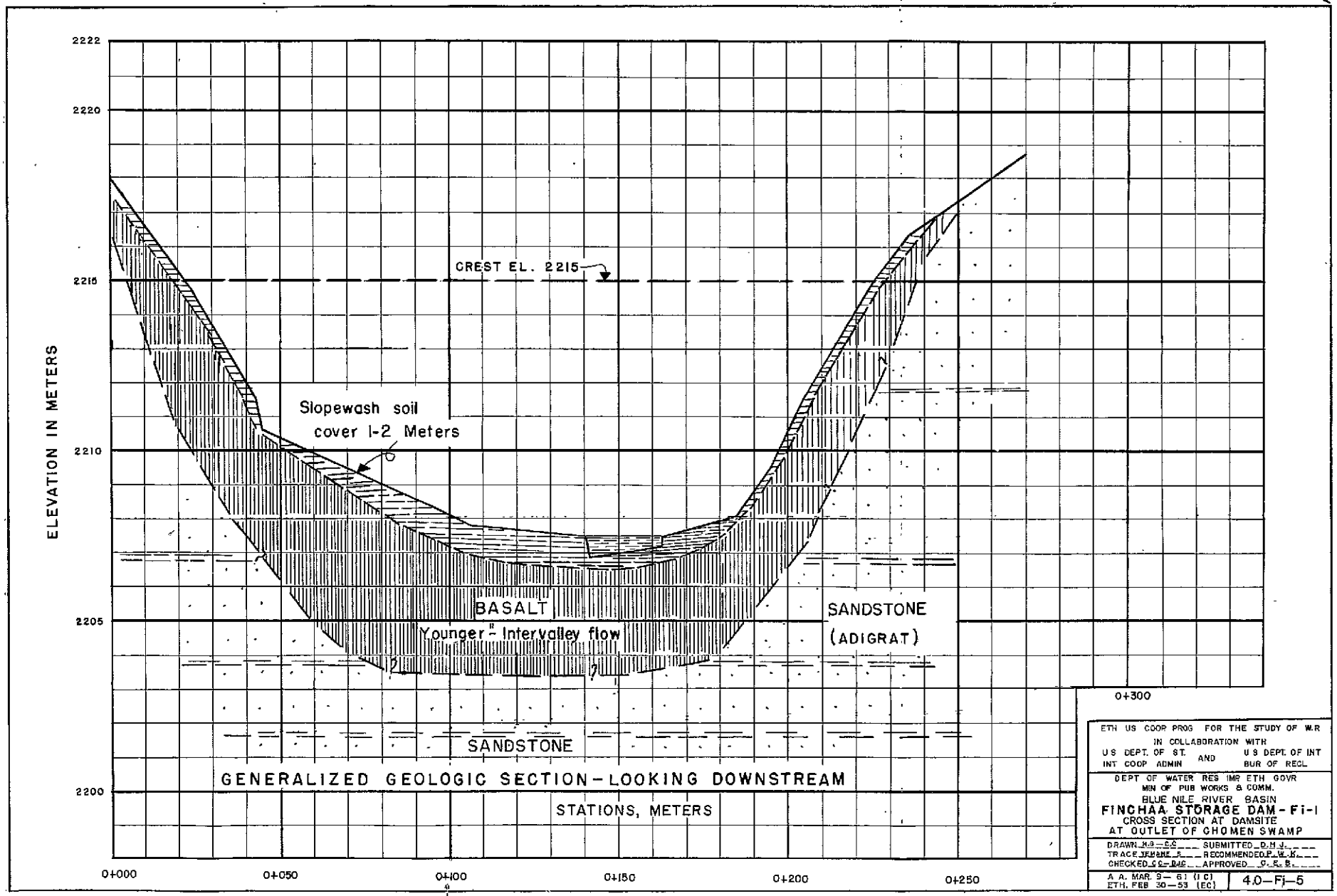
FINCHAA DAM & RESERVOIR

AREA CAPACITY DATA

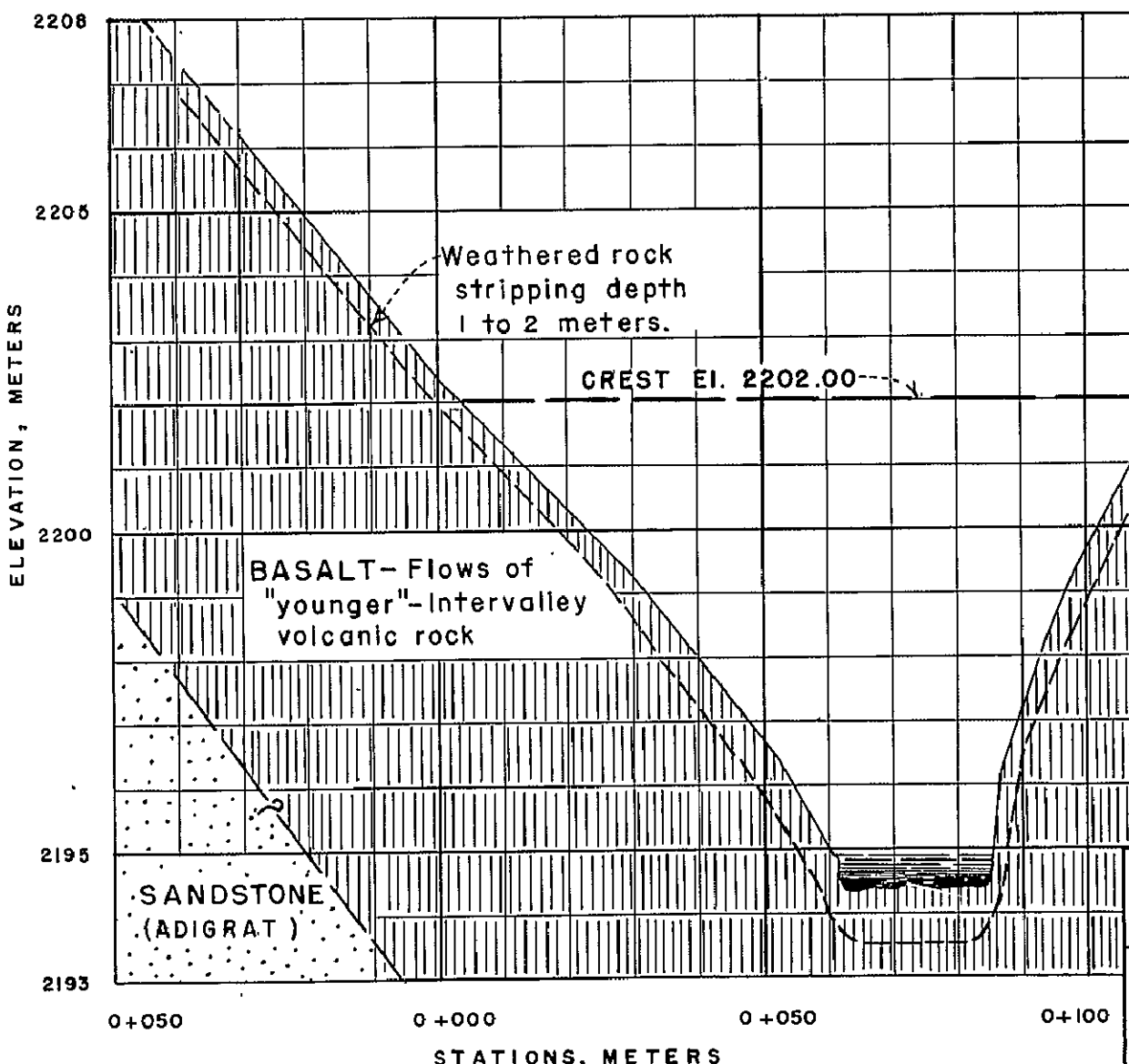
(with sediment distributed)

CONTROL POINTS				INITIAL AREA	CAPACITY (CUBIC METERS – 10^6)			
ITEM & ALLOCATION OF STORAGE CAPACITY		DIAGRAM OF DAM	ELEVATION (METERS)	(SQ. METERS – 10^6)	INITIAL		WITH 50-YR. SEDIMENT	
					INCREMENT	TOTAL	INCREMENT	TOTAL
TOP OF DAM			2215.00					
MAXIMUM W.S.	FREEBOARD		2214.23	251.4		680.9		648.2
NORMAL W.S	FLOOD SURCHARGE		2213.40	188.00	216.9	464.0	216.9	431.3
	ACTIVE CAPACITY				419.3		400.1	
MINIMUM OPERATING W.S.			2210.00	56.65		44.7		31.2
LIP OF LOWEST OUTLET*	INACTIVE CAPACITY		2208.00	3.70	43.3	1.4	31.2	0
	DEAD STORAGE AND SILT				1.4		0	
STREAM BED			2207.00	0		0		0

*100-YEAR SEDIMENT OF 66,000,000 M^3 WILL TAKE 2208.85 METERS ELEVATION AT THE DAM.



GENERALIZED GEOLOGIC SECTION—LOOKING DOWNSTREAM



GENERALIZED GEOLOGIC SECTION-LOOKING DOWNSTREAM

ETH US COOP PROG. FOR THE STUDY OF W R
IN COLLABORATION WITH
U.S. DEPT OF ST. INT. COOP. ADMIN. AND U.S. DEPT OF INT. BUR OF RECL

DEPT. OF WATER RES. IMP. ETH. GOVR.
MIN. OF PUB. WORKS & COMM
BLUE NILE BASIN

FINCHAA POWER DIVERSION DAM
CROSS SECTION AT DAMSITE ON
FINCHAA RIVER BELOW CHOMEN SWAMP

DRAWN HG-GC SUBMITTED D.H.J.
TRACED NEGASH RECOMMENDED P.W.K.
CHECKED P.K. APPROVED C.E.B.

A.A. MAR. 17-1961
ETH. MAR. 8-1953

4.0-Fi-9

Access to Sites

Access to the project would have to be improved--that is, the 135 kilometers of trail from Gedo to the Finchaa damsite. This section of the road is considered for the purpose of this estimate as part of the national road system and therefore is not included as part of the project cost. However, access roads to the other project features would be necessary.

1. Road from Finchaa Dam to power diversion dam, following edge of swampy ground--five kilometers.

2. Road from power diversion dam over the escarpment to powerplant--20 kilometers.

3. Road from powerplant to irrigation diversion dam, following Finchaa River through rolling hills--five kilometers.

Power Diversion Dam

This structure is on the Finchaa River approximately 200 meters upstream from the lip of the falls. The reservoir will store 90,900 cubic meters above the minimum operating water surface elevation. It would be a masonry overflow dam with a maximum height of about 7.5 meters above river bed. The crest length includes about 40 meters for an ogee spillway section. The inlet structure for the power tunnel would be located on the right abutment and gated for emergency closure to the tunnel. See Drawing No. OA-23-101 for plan and section of dam.

Power Dam Data

Type	masonry-ogee
Volume of masonry	1,320 cu. m.
Normal water surface elevation	2200 m.
Spillway crest elevation	2200 m.
Structural height	7.5 m.
Hydraulic height	5.5 m.
Length of crest	114 m.

Power Tunnel and Penstocks

The tunnel, starting at the inlet portal near the right abutment of the power diversion dam at elevation 2195.6 meters, would be a pressure-type tunnel requiring reinforced concrete linings. It would be about 330 meters long, would be 2.2 meters in diameter, and would have a design capacity of 19 cubic meters per second. The increased hydraulic head and the poor rock formations will require a welded

steel pipe to be encased in prolongation of the tunnel for a distance of 1,210 meters, thence under cut-and-cover section for another 320 meters. Two penstocks, each having a diameter of 1.524 meters, would then be connected with butterfly valves above ground for a distance of 1,280 meters, terminating at the powerplant at elevation 1715 meters.

Tunnel Data

Type	pressure
Length	330 m.
Diameter	2.2 m.
Design capacity 1/	19 cu. m. per sec.

Welded Steel Pipe and Penstock Data

Welded Steel	
Length	1,530 m.
Diameter	2.2 m.
Design capacity	19 cu. m. per sec.
Penstocks (two)	
Length (each)	1,280 m.
Diameter (each)	1.524 m.

Powerplant

Drawing No. 4.0-BN-74 gives an indication of the river profile together with the elevations of the pertinent structures, including the powerplant. Conveyance of water from the forebay storage to the powerplant turbines would be by pressure tunnel and welded steel penstock. According to operation studies made (SECTION III), the annual gross generation would be 360,420,000 kw.-hr. for an adverse water supply period. Two generator units of 40 mw. each would be satisfactory, providing a total plant capacity of 80 mw. or 100 mv.-a. at 0.8 power factor.

Because of the high head, 467 meters (net), the two turbines will be of the impulse-type, each rated 55,725 metric hp. (56,500 English hp.) and could be double-runner with a single jet per runner. Horizontal shaft, double-overhung, single-nozzle, 429-r.p.m. wheels would be adequate. The pitch diameter of the runner would be about 208 centimeters, and the jet diameter would be about 27 centimeters. The diameter of the nozzle pipe would be about 130 centimeters with the velocity of the water through the

1/Designs permit meeting annual load factor at plant of 58%.

nozzle pipe inlet determined to be about 8.5 meters per second. The width of the wheel pit would be slightly over three meters, and the flow of water to the turbines would be controlled by a needle valve from governor action related to load demand. The governor action would also simultaneously operate a pressure regulator to by-pass water from the penstock, during load changes, around the turbine into the tailrace. Energy absorbers are required to dissipate water from the pressure regulators. Thus, there will be no sudden changes in the velocity of the water in the tunnel and penstocks due to load pick-up or rejection.

The two generators would have individual step-up transformers, as shown by Drawing No. 4.0-Fi-8, from 13.8-kv. generator voltage to 161-kv. transmission voltage, each transformer rated 50,000 kv.-a. Generator units 1 and 2 will provide station service power, stepping from 13.8-kv. to 220-volt, three-phase, by means of a 300-kv.-a. transformer connected to each unit, electrically interlocked so that only one transformer is energized at one time. This source will also serve the caretakers' and operators' quarters. The switchyard is to be arranged so that future 45-kv. and 12.47-kv. lines can be terminated.

Summarizing, the generators would have the following characteristics.

Speed	429 r.p.m.
Number of poles	14
Horizontal shaft, direct connected	
Voltage (wye connected)	13.8 kv.
Frequency	50 cycles
Power factor, variable, 0.8 thru unity, lag or lead	

Transmission Plant

Transmission Lines. Assuming that the Finchaa powerplant will be the first Blue Nile plant to serve the Addis Ababa Complex, followed next by the Neshe powerplant (30 km. from the Finchaa powerplant), a double-circuit, steel tower, transmission line with one circuit installed initially and rated at 161 kv. would be constructed simultaneously with the Finchaa powerplant from the Dongi Substation, 1/ located on the escarpment above the powerplant, to Addis Ababa. Later, the second circuit would be installed on these existing towers when the Neshe powerplant is constructed, thus completing the double-circuit line. A 1.8-kilometer, single-circuit, steel tower line would be required from the Finchaa switchyard to Dongi Substation.

1/Named after the lower section of Chomen Swamp, known as Dongi Swamp to the local people.

82

Prior to construction of Neshe, there will be about 249.8 km. of 161-kv. line, consisting of 1.8 kilometers of single-circuit tower construction joining the 248 km. of double-circuit tower construction carrying one circuit. The junction point would be the future site of the Dongi Substation, required when Neshe is constructed.

The transmission distance (airline) from Addis Ababa to the Finchaa powerplant would be about 170 kilometers (100 miles) and would cross some very rough and nearly inaccessible terrain. Access to a line along this route would be a serious problem and almost prohibitive in cost. For these reasons, the routing shown on Drawing No. 4.0-BN-170 (SECTION VII)--generally south along the east side of the swamp toward Gedo and thence along the main highway to Addis Ababa--may be the most feasible at this time, even though 240 kilometers (150 miles) in length. The latter route can presently be traveled all year from Addis Ababa to Gedo but only during the dry season from Gedo to the edge of the escarpment overlooking the powerplant below.

The transmission line will provide satisfactory service using 954,000 circular mil ASCR conductor based upon USBR standards, although some utilities might consider that 795,000 circular mil would be adequate. Cost estimates here, however, are based upon using 954,000 circular mil ACSR.

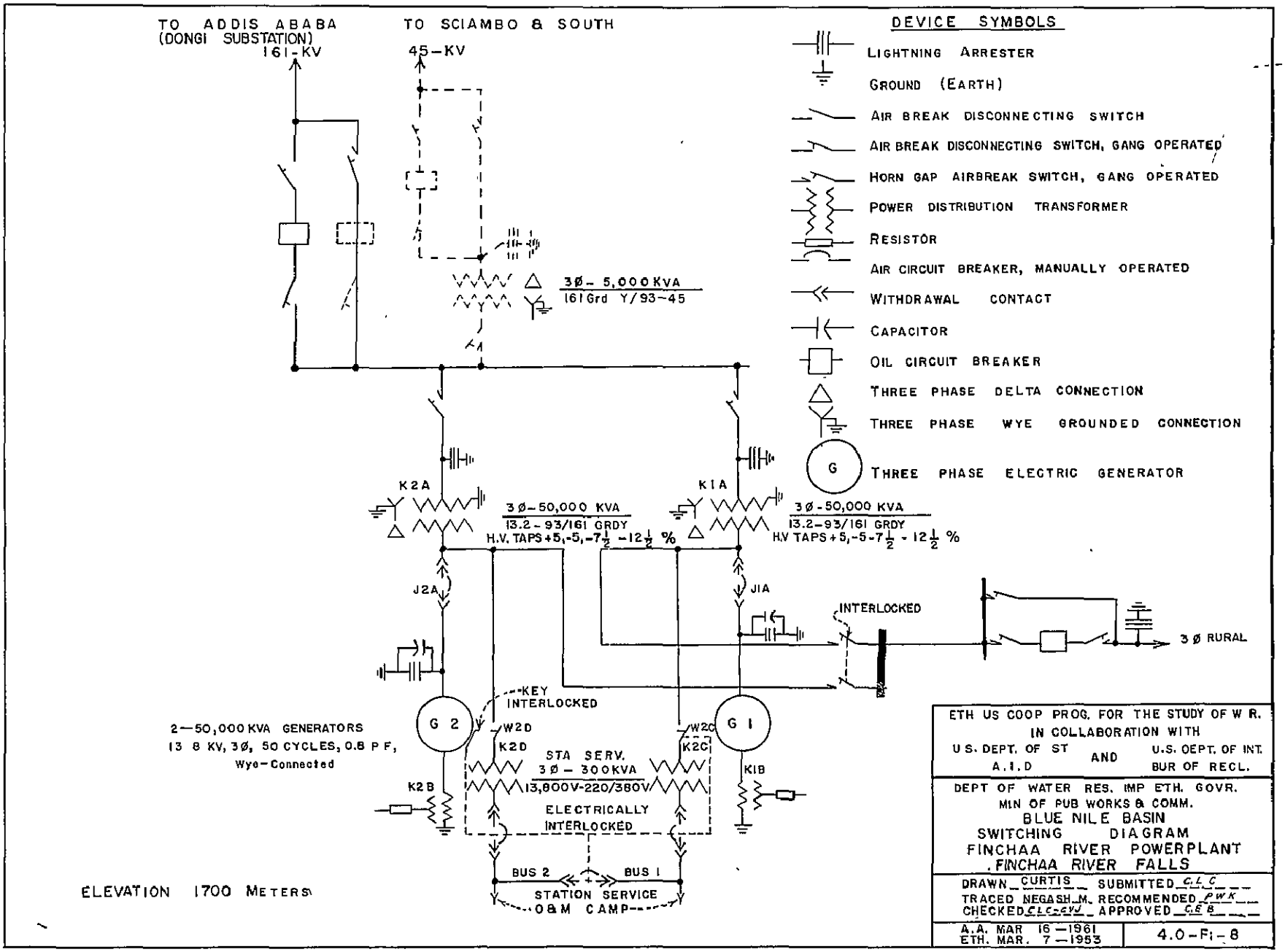
A 230-kv. line was avoided because at some of the altitudes the line will traverse, corona loss would require larger conductors resulting in higher cost. Also, the higher voltage was avoided for operational reasons, as the highest voltage used so far is 132 kv. The special problems associated with 230 kv. should be avoided at the present stage of electrification.

Impregnated eucalyptus poles were considered for two separate 161-kv. lines, but they were decided against at this time for the following reasons:

1. Lack of experience data concerning service lives of these treated poles.

2. The annual prevalent practice of burning off the bush after the end of the rains may cause destruction of some of the wood-pole structures.

Steel tower lines, although requiring greater initial investment, may have lower annual costs because of the higher OM&R for the wood-pole lines. Until the reliability of the treated eucalyptus poles is demonstrated by successfully resisting dry rot and termites, steel was the choice for this project.


TO ADDIS ABABA
(DONGI SUBSTATION)
161-KV
TO SCIAMBO & SOUTH
45-KV
3Ø- 5,000 KVA
161 Grd Y/93-45
DEVICE SYMBOLS
LIGHTNING ARRESTER
GROUND (EARTH)
AIR BREAK DISCONNECTING SWITCH
AIR BREAK DISCONNECTING SWITCH, GANG OPERATED
HORN GAP AIRBREAK SWITCH, GANG OPERATED
POWER DISTRIBUTION TRANSFORMER
RESISTOR
AIR CIRCUIT BREAKER, MANUALLY OPERATED
WITHDRAWAL CONTACT
CAPACITOR
OIL CIRCUIT BREAKER
THREE PHASE DELTA CONNECTION
THREE PHASE WYE GROUNDED CONNECTION
G
THREE PHASE ELECTRIC GENERATOR
K2A
3Ø-50,000 KVA
13.2-93/161 GRDY
H.V. TAPS +5,-5,-7½ -12½ %
K1A
3Ø-50,000 KVA
13.2-93/161 GRDY
H.V TAPS +5,-5-7½ - 12½ %
J2A
J1A
INTERLOCKED
3Ø RURAL
KEY
INTERLOCKED
2—50,000 KVA GENERATORS
13 8 KV, 3Ø, 50 CYCLES, 0.8 P F,
Wye-Connected
G 2
G 1
W2D
W2C
K2D
K2C
STA SERV.
3Ø- 300KVA
13,800V-220/380V
ELECTRICALLY
INTERLOCKED
K2B
K1B
BUS 2
BUS 1
STATION SERVICE
O&M CAMP
ELEVATION 1700 METERS
ETH US COOP PROG. FOR THE STUDY OF W R.
IN COLLABORATION WITH
U.S. DEPT. OF ST
A.I.D
AND
U.S. DEPT. OF INT.
BUR OF RECL.
DEPT OF WATER RES. IMP ETH. GOVR.
MIN OF PUB WORKS & COMM.
BLUE NILE BASIN
SWITCHING DIAGRAM
FINCHAA RIVER POWERPLANT
FINCHAA RIVER FALLS
DRAWN CURTIS SUBMITTED C.L.C.
TRACED NEGASH.M. RECOMMENDED P.W.K.
CHECKED C.L.C.-C.V.J. APPROVED C.E.B.
A.A. MAR 16—1961
ETH. MAR. 7—1953
4.0-F1-8

Provisions have been made for future facilities to serve local loads, although it is believed that it will not be possible to serve rural areas for many years as it has been proven elsewhere that developing countries in early stages of electrification cannot afford rural electrification. Therefore, delivery of the entire net plant output will undoubtedly be utilized in the Addis Ababa Complex, or possibly in addition at some of the larger urban centers within transmission distance. (These two cases have been studied; see SECTION VII.)

Concerning a long-range development program to provide electricity for the Chomen Swamp area, a 45-kv. line around the north and west sides of the swamp, serving Shambo, Haratu, and Gedo, may eventually be justified. The distance is 110 km. (66 miles). Ultimately, with increased loads, a 161/45-kv. substation can be installed at Gedo, completing a loop. The same substation could supply Lekkemt at 45-kv.

Substation. By 1971, EELPA will have constructed the Sebeta (Sabata) and Gafarsa Substation No. 1 west of Addis Ababa as part of a basic plan to provide a 132-kv. ring bus around the city. (See Dwg. No. 4.0-Et-14, SECTION VII.) The 161-kv. lines from the Finchaa Sub-Basin powerplants can either terminate in 161- and 132-kv. additions to Gafarsa Substation No. 1 or in a separate substation which can eventually be expanded to include 230-kv. in the future. Since there might be an advantage in having another substation as part of the ring bus extension located to the north or northeast of the center of the city, a separate substation identified as Gafarsa No. 2 has been used for estimating purposes, as shown by Drawing No. 4.0-BN-174 with the 1980 system shown on Drawing No. 4.0-Et-15 (SECTION VII).

The substation will be of the outdoor type with controls and service equipment located indoors. One control house and one combination service building-warehouse will be necessary. A double-bus, single-breaker scheme with one transfer breaker per voltage section is used, but the latter breaker is installed only when warranted. Connections are made according to American practice, which uses one main and one auxiliary bus whereas the European practice uses two main buses. Construction costs of both arrangements are about equal and both types have advantages. Since costs are about equal, the American practice is used here, as a major purpose of designs at this reconnaissance stage is to arrive at approximate estimates of cost. Ultimately, when these facilities are investigated and designed for final construction, such designs may well follow European practice. These conditions also apply to powerplant switchyards. Standard A.S.A. electrical symbols are used as portrayed by Drawing No. 4.0-BN-23.

85

The terminal facilities required in the receiving-end substation, Gafarsa No. 2, for the first 161-kv. line (from Finchaa powerplant) will consist of a 161-kv. line bay, transformer bay, 161/132-kv. autotransformer bay, and three 132-kv. bays (two-line bays) as explained by Note 1 on Drawing No. 4.0-BN-174. These facilities have been designated as Stage 01.

Irrigation Diversion Dam

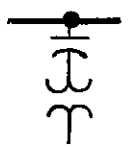
The irrigation diversion damsite would be located on the Finchaa River approximately 11 kilometers downstream from the powerplant. There would be no significant amount of storage in the diversion reservoir. Headworks for two radial gates would be provided, one for the East Main Canal designed to discharge 10.5 cubic meters per second, the other for a flow of 8.5 cubic meters per second with a sluiceway for each headworks for sediment disposition. The ogee-type spillway envisioned for this dam is estimated to be 210 meters in length.

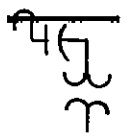
Irrigation Diversion Dam Data

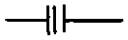
Volume of masonry	2,650 cu. m.
Maximum water surface elevation	1602.25 m.
Normal water surface elevation	1600.5 m.
Structural height	3.5 m.
Elevation at top of dam	1602.6 m.
Maximum flood discharge	900 cu. m. per sec.
Crest length	292 m.

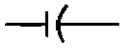
Main Canals

Two main canals starting from the outlet works of the diversion dam on each side of the river have been planned for the project to convey water by gravity to serve as much as possible of the lands determined to be arable. The location would traverse rolling hills and cross many ravines and draws which will require suitable structures to accommodate the high flows of the rainy season. The proposed route would be for the most part in the fairly deep soils of the valley, but short reaches might possibly be in sandstone where soil cover is thin or entirely absent. No problem should be encountered from constructing the canal as an open, unlined section. Clearing will be a definite problem, present vegetation varying from dense growths of large trees in many areas to scattered trees with tall grasses. Structures such as bridges, culverts, wasteways, turnouts, siphons, checks, and drops would have to be provided as required. The cost of these structures has been estimated, using the Upper Guder Project as a prototype, on the assumption that it closely approximates the structure requirements for the Finchaa Project.

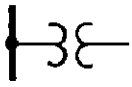

Capacitor potential device


Bushing potential device


Lightning arrester


Capacitor

Ground (earth) connection

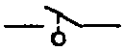

Potential transformer

Current transformer, wound type

Current transformer, bushing type

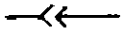
Disconnecting switch, gang operated

Horn gap airbreak switch, gang operated

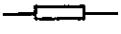

Disconnecting switch, motor operated

Oil circuit breaker

Air circuit breaker, manually operated


Withdrawal contact

Fuse

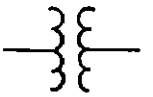

Resistor

Generator

Cable pothead

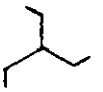
Electrical connection

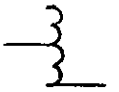
No connection


Power transformer

3 ϕ, Wye grounded connection

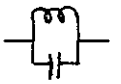
3 ϕ, Delta connection


3 ϕ, Zigzag connection


Auto transformer

Fused disconnecting switch

Interrupter switch


Carrier current wave trap

Disconnecting switch, hook-stick operated

Synchronous condenser

Base upon A.S.A. Graphical symbols

ETH-US COOP PROG. FOR THE STUD. OF WATER R.
IN COLLABORATION WITH
U.S. DEPT OF ST AGENCY FOR INT.DEV AND U.S DEPT OF INT. BUR OF RECL

DEPT OF WATER RES. IMP. ETH GOVERNMENT
MIN. OF PUB WORKS & COMM
BLUE NILE RIVER BASIN

RECONNAISSANCE DESIGNS
DEVICE DESIGNATIONS - SYMBOLS FOR SWITCHING DIAGRAMS

DRAWN C.L. Curtis SUBMITTED C.L.C.
TRACED Sabra Christos RECOMMENDED P.W.K.
CHECKED C.L.C. APPROVED C.E.B.

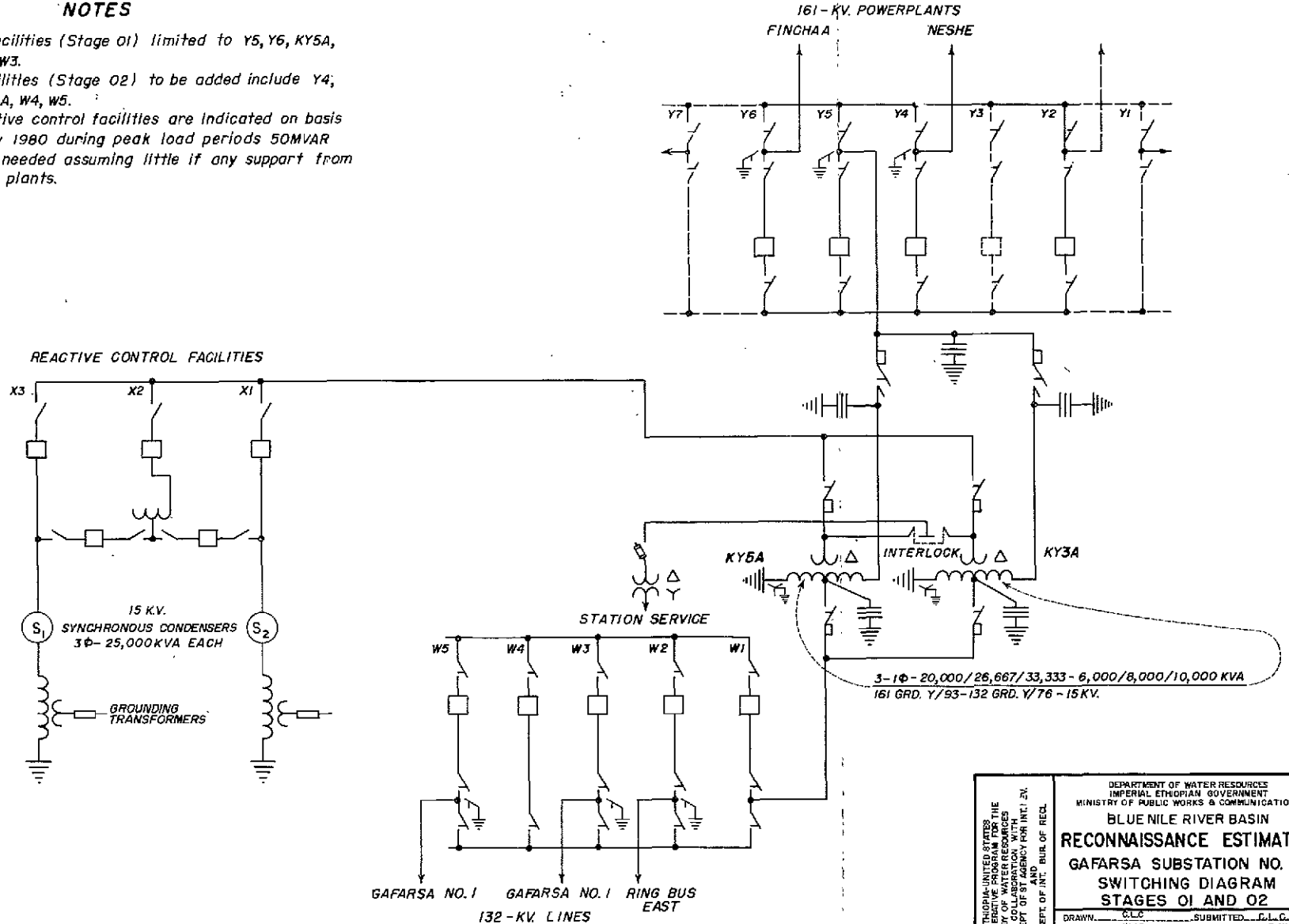
A A Mar. 14 - 1962 (I C)
ETH. Mar. 5 - 1954 (E C)

4-0-BN-23

81

NOTES

1. Finchaa facilities (Stage 01) limited to Y5, Y6, KY5A, W1, W2, W3.
2. Neshe facilities (Stage 02) to be added include Y4, Y2, KY3A, W4, W5.
3. Some reactive control facilities are indicated on basis that by 1980 during peak load periods 50MVAR will be needed assuming little if any suppart from Awash plants.



APPROXIMATE ELEVATION 2560 METERS

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT OF ST AGENCY FOR INT. DEV. AND U.S. DEPT. OF INT. BUR. OF RECL

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

RECONNAISSANCE ESTIMATES

GAFARSA SUBSTATION NO. 2
SWITCHING DIAGRAM
STAGES 01 AND 02

DRAWN	C.L.C.	SUBMITTED	C.L.C.
TRACED	W.J.G.	RECOMMENDED	P.W.K.
CHECKED	D.J.C.	APPROVED	C.E.B.

Addis Ababa Ethiopia NOVEMBER 13, 1963

4.0-BN-174

East Main Canal. The East Main Canal would originate at the discharge end of the outlet works on the right abutment of the irrigation diversion dam. It would extend in a northerly direction for a distance of approximately 56.7 kilometers and would have an initial capacity of 10.2 cubic meters per second. This canal would convey water by gravity to serve approximately 8,000 hectares of irrigable lands.

East Main Canal Data

Length	56.7 km.
Type	unlined
Initial capacity	10.2 cu. m. per sec.
Initial water surface elevation	1600 m.

West Main Canal. The West Main Canal would extend from the discharge end of the outlet works, on the left abutment of the irrigation diversion dam. It would proceed in a northerly direction for a distance of approximately 43.1 kilometers and would have an initial capacity of 8.5 cubic meters per second. The canal would convey water by gravity to serve approximately 7,000 hectares of irrigable land on the west side of the Finchaa River.

West Main Canal Data

Length	43.1 km.
Type	unlined
Initial capacity	8.5 cu. m. per sec.
Initial water surface elevation	1600 m.

Distribution System and Drains

Distribution System. The irrigable lands occur on broad-topped ridges varying in width from 300 to 1,000 meters with slopes of one to two percent, lending themselves readily to water-spreading with a minimum expense of land leveling, increasing in slope on the sides of the ridges up to 12 percent. Distribution of water to the lands with the steeper gradients will be more difficult and costly to develop than those on the plateaus, with particular attention necessary for the prevention of erosion. The distribution system for the 15,000 hectares of irrigable lands is envisioned as an open, unlined canal with sufficient capacity to meet the peak demand of any lateral service area during the period of maximum demand. The distribution system has been planned on the basis that the application of water for the area would be on a continuous 24-hour operation when required, based on a rotation system of irrigation. Included in the cost estimate are farm turnouts that would be provided for about every 17 hectares of land, with metal slide gate and meter-type

measuring devices leading to a concrete pipe. Other structures required would include drops, checks, culverts, and farm crossings. Costs for the distribution system were computed on a cost per hectare basis derived from semidetailed studies performed on the Upper Birr Project. The estimated cost of Eth$330 per hectare was used, which excludes contingencies, engineering, and general expense.

Drains. Costs have been estimated for construction of surface drainage to be provided for removal of irrigation waste and excess precipitation falling on the irrigable lands. The erosiveness of the soils and the fast slope of the lands are such that without proper drainage the erosion would develop numerous, deep, vertically walled drainageways that would wash away the soil resources. The natural drainage channels would be used for outlet purposes wherever practicable and would be protected and improved wherever necessary or desirable. Based upon the Upper Birr Project, where semidetailed studies were performed, the cost per hectare was estimated to be Eth$120 on the assumption that the natural drainage channels were more numerous than those of the prototype, and excluding contingencies, engineering, and general expense.

Estimates for subsurface drainage requirements were not possible because of lack of data. Further studies to determine the requirements and feasibility of subsurface drains would include existing water table behaviour, any subsurface obstructions such as dikes that would impound water, an evaluation of present vegetation for evidence of wet areas, and suitable pump-in tests to determine the in-place permeability. It is emphasized that if subsurface drainage is found necessary, the cost would add a significant amount to the total project cost.

Service Facilities

Housing and administrative buildings will be required by government personnel to administer and oversee that the construction of the features follows the contract specifications and later to house operation and maintenance personnel. Cost generally associated with this item includes camps, construction roads and trails, utility systems, transportation equipment, and cost of temporary plant used during construction. The estimates for this item, in the absence of local data, were based on United States Bureau of Reclamation practices modified to local requirements. Generally, cost per square meter was employed, using prices prevailing in Addis Ababa for construction of the various buildings estimated to be required.

Estimates of Construction Cost

The total construction cost for the multipurpose Finchaa Project is estimated at Eth$86,127,000 on the basis of January 1961

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN—ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project FINCHAA--Multiple-purpose

Date of Estimate November 1963

Prices as of January 1961

Currency in terms of Ethiopian Dollars

(U S $ 1.00 = Eth. $ 2.50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	FINCHAA PROJECT--Multiple-purpose					71,740,500	86,127,000
	Joint-use features					(3,893,200)	(4,838,000)
	Power features					(54,940,400)	(65,177,000)
	Irrigation features					(12,906,900)	(16,112,000)
	FINCHAA STORAGE DAM--Stone masonry dam with 50 meter ogee spillway; crest length, 210 meters; height of dam 6.4 meters. Joint-use. Dwg. OA-23-101					568,200	682,000
1	Diversion and care of river	Lump Sum		Lump Sum	9,400		
2	Excavation, common	1,400	m^3	1.95	2,730		
3	Excavation, rock	340	m^3	8.00	2,720		
4	Pressure grouting, all work and material	Lump Sum		Lump Sum	26,700		
5	Masonry in abutments	2,115	m^3	70.00	148,050		
6	Masonry in spillway	1,300	m^3	70.00	91,000		
7	Concrete in spillway crest and bucket	160	m^3	180.00	28,800		
8	Concrete in outlet works	215	m^3	210.00	45,150		
9	Reinforcement	13,000	kg	1.00	13,000		
10	Drilling drainage holes	140	lm	25.00	3,500		
11	Drainage pipe, concrete 10 cm diameter	120	lm	12.60	1,512		
12	Drainage pipe, concrete 20 cm diameter	20	lm	21.00	420		
13	Handrail, 0.05 m. diameter	988	kg	2.60	2,569		
14	Slide gates, 2 - 2.0 X 2.0 m, cast iron and motor operated hoists	14,370	kg	5.50	79,035		
	Subtotal				454,586		
	Contingencies (25±%)				113,614		
	Field Cost--Finchaa Storage Dam				568,200		
	Engineering and General Expense (20±%)				113,800		
	Total est. const. cost--Finchaa Storage Dam				682,000		
	POWER DIVERSION DAM--Stone masonry dam with 40 meter ogee spillway; crest length, 114 meters; height of dam 7.5 meters Dwg. OA-23-101					174,600	210,000
1	Diversion and care of river	Lump Sum		Lump Sum	2,000		
2	Excavation, rock	800	m^3	8.00	6,400		
3	Masonry in spillway	790	m^3	70.00	55,300		
4	Masonry in abutments	530	m^3	70.00	37,100		
5	Concrete in spillway crest and bucket	130	m^3	180.00	23,400		
6	Pressure grouting, all work and material	Lump Sum		Lump Sum	15,500		
	Subtotal				139,700		
	Contingencies (25±%)				34,900		
	Field Cost--Power Diversion Dam				174,600		
	Engineering and General Expense (20±%)				35,400		
	Total est. const. cost--Power Diversion Dam				210,000		
	IRRIGATION DIVERSION DAM--Stone masonry dam with 210 meter ogee spillway; crest length, 292 meters; height of dam, 3.5 meters					454,000	545,000
1	Diversion and care of river	Lump Sum		Lump Sum	15,000		
2	Excavation, common, for weir and structures	14,700	m^3	1.95	28,665		
3	Excavation, rock for weir and structures	7,000	m^3	8.00	56,000		
4	Masonry in weir	2,400	m^3	70.00	168,000		
5	Masonry in abutments	250	m^3	70.00	17,500		
6	Concrete in headworks and sluiceways	174	m^3	210.00	36,540		
7	Pressure grouting foundations	292	lm	83.00	24,236		
8	Gates, gate hoists, handrails and etc.	Lump Sum		Lump Sum	17,200		
	Subtotal				363,141		
	Contingencies (25±%)				90,859		
	Field Cost--Irrigation Diversion Dam				454,000		
	Engineering and General Expense (20±%)				91,000		
	Total est. const. cost--Irr. Diversion Dam				545,000		

TABLE V-1

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN—ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project FINCHAA--Multiple-purpose

Date of Estimate November 1963

Prices as of January 1961

Currency in terms of Ethiopian Dollars

(U.S. $1.00 = Eth. $2.50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	TUNNEL AND PENSTOCKS--Diameter 2.2 meters; 330 meters reinforced conc. lined tunnel, 880 meters penstock in tunnel, 320 meter penstock in cut and cover. Two barrels, penstock diameter 1.524 meters, length 1280 meters, above ground. Max. head 536 meters. Plate thickness, 22.2 to 38.1 mm.					28,650,800	32,948,000
1	Excavation, all classes in open cut	12,500	m^3	3.25	40,625		
2	Excavation, tunnel	9,850	m^3	120.00	1,182,000		
3	Backfill, select, cut and cover section	11,300	m^3	2.50	28,250		
4	Concrete in tunnel lining	512	m^3	238.00	121,856		
5	Concrete behind penstock in tunnel	6,830	m^3	150.00	1,024,500		
6	Reinforcement in tunnel lining	43,500	kg	1.12	48,720		
7	Tunnel supports and lagging	Lump Sum		Lump Sum	284,000		
8	Grouting and drainage	Lump Sum		Lump Sum	213,000		
9	Steel penstocks, above and below ground	5,193,500	kg	3.43	17,813,705		
10	Piers and anchorages for penstocks	Lump Sum		Lump Sum	1,794,000		
11	Butterfly valves and controls, 2-1.68 m dia.	69,100	kg	4.12	284,692		
	Tunnel Intake Structure						
12	Excavation, common	140	m^3	1.95	273		
13	Excavation, rock	50	m^3	8.00	400		
14	Fill, misc. rock, access to structure	1,252	m^3	5.75	7,199		
15	Concrete in superstructure	90	m^3	210.00	18,900		
16	Concrete in substructure	130	m^3	150.00	19,500		
17	Reinforcement	11,700	kg	1.00	11,700		
18	Masonry in retaining walls	40	m^3	70.00	2,800		
19	Trashracks and miscellaneous metalwork	2,500	kg	2.60	6,500		
20	Slide gate, 2.2 X 2.2 meters	6,000	kg	3.00	18,000		
	Subtotal				22,920,620		
	Contingencies (25±%)				5,730,180		
	Field Cost--Tunnel and Penstocks				28,650,800		
	Engineering and General Expense (15±%)				4,297,200		
	Total est. const. cost--Tunnel and Penstocks				32,948,000		
	IRRIGATION CANALS--Unlined					4,015,400	5,020,000
	East Main Canal and Laterals over 1.0 cu. meters/sec. Length, 101.1 kms; capacity, 10.5 to 1.0 cu. meters/sec.					(2,424,600)	(3,031,000)
1	Canal excavation, common	782,370	m^3	0.82	641,543		
2	Canal excavation, rock	15,970	m^3	8.00	127,760		
3	Compacting embankment	204,610	m^3	0.98	200,518		
4	Structures, concrete and masonry	Lump Sum		Lump Sum	814,650		
5	Gates, hoists, values and miscellaneous metalwork	Lump Sum		Lump Sum	19,400		
6	Concrete pipe	Lump Sum		Lump Sum	38,800		
7	Other miscellaneous work	Lump Sum		Lump Sum	96,980		
	Subtotal				1,939,651		
	Contingencies (25±%)				484,949		
	Field Cost--East Main Canal				2,424,600		
	Engineering and General Expense (25±%)				606,400		
	Total est. const. cost--East Main Canal				3,031,000		

TABLE V-1

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN—ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project FINCHAA—Multiple-purpose

Date of Estimate November 1963

Currency in terms of Ethiopian Dollars

Prices as of January 1961

(U S $ 1.00 = Eth $ 2 50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	IRRIGATION CANALS—Unlined (Continued)						
	West Main Canal and Laterals over 1.0 cu. meters/sec. Length, 73.9 kms; capacity, 8.5 to 1.2 cu. meters/sec.					(1,590,800)	(1,989,000)
1	Canal excavation, common	514,740	m^3	0.82	422,087		
2	Canal excavation, rock	10,500	m^3	8.00	84,000		
3	Compacting embankment	132,870	m^3	0.98	130,213		
4	Structures, concrete and masonry	Lump Sum		Lump Sum	534,500		
5	Gates, hoists, values and miscellaneous metalwork	Lump Sum		Lump Sum	12,700		
6	Concrete pipe	Lump Sum		Lump Sum	25,500		
7	Other miscellaneous work	Lump Sum		Lump Sum	63,630		
	Subtotal				1,272,630		
	Contingencies (25±%)				318,170		
	Field Cost—West Main Canal				1,590,800		
	Engineering and General Expense (25±%)				398,200		
	Total est. const. cost—West Main Canal				1,989,000		
	IRRIGATION DISTRIBUTION SYSTEM—Open lateral, unlined system for 15,000 net hectares on both sides of the Finchaa River					6,187,500	7,734,000
1	Finchaa Project distribution system	15,000	ha	330.00	4,950,000		
	Contingencies (25±%)				1,237,500		
	Field Cost—Distribution system				6,187,500		
	Engineering and General Expense (25±%)				1,546,500		
	Total est. const. cost—Distribution system				7,734,000		
	DRAINAGE SYSTEM—Open land drains for 15,000 net hectares of irrigated land					2,250,000	2,813,000
1	Finchaa Project drains	15,000	ha	120.00	1,800,000		
	Contingencies (25±%)				450,000		
	Field Cost—Drains				2,250,000		
	Engineering and General Expense (25±%)				563,000		
	Total est. const. cost—Drains				2,813,000		
	POWERPLANT—Hydro.					8,812,000	11,015,000
1	Structures and improvements, masonry and reinforced concrete	Lump Sum		Lump Sum	1,800,000	(1,800,000)	
	Waterways						
2	Tailrace excavation, common	Lump Sum		Lump Sum	162,000	(162,000)	
3	Turbines and generators—Two units 50,000 KVA, 13.2 KV, 0.8 pf, 50 cycle generators and 56,500 hp, 429 rpm, 467 meter head impulse type horizontal turbines	Lump Sum		Lump Sum	4,800,000	(4,800,000)	
4	Accessory electrical equipment—All equipment required for control and protection of generators and station service power	Lump Sum		Lump Sum	1,100,000	(1,100,000)	
5	Miscellaneous equipment—Required for general station use	Lump Sum		Lump Sum	700,000	(700,000)	
6	Access road—Two lane crushed rock from Irr. Div. Dam to Powerplant	5	kms	40,000.00	200,000	(250,000)	
	Contingencies (25±%)				50,000		
	Engineering and General Expense (25±%)						(2,203,000)

TABLE V-1

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN—ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project: FINCHAA--Multiple-purpose

Date of Estimate: November 1963

Currency in terms of Ethiopian Dollars

Prices as of: January 1961

(U S $ 1 00 = Eth $ 2 50)

ITEM NO	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	TRANSMISSION LINES, SWITCHYARDS AND SUBSTATIONS					17,303,000	21,004,000
1	Finchaa switchyards--Located near powerplant					(1,863,000)	
	Single breaker line bay, 161 KV, 1,200 ampere, complete	Lump Sum		Lump Sum	300,000		
	Single bay 161 KV, 1,200 ampere switch installations only	Lump Sum		Lump Sum	100,000		
	Single breaker line bay 15 KV, complete	Lump Sum		Lump Sum	32,000		
	Transformers, two required, three-phase, 50,000 KVA, 13.2-93/161-KV installation complete	Lump Sum		Lump Sum	1,431,000		
	Engineering and General Expense (25±%)						(465,500)
2	Transmission line--Finchaa Switchyard to Dongi Substation 161 KV, single-circuit steel towers with one overhead ground wire and three 954 MCM ACSR conductors. Rough terrain, much clearing.	1.8	kms	50,000.00	90,000	(90,000)	
	Engineering and General Expense (20±%)						(18,000)
3	Transmission line--Dongi Substation to Gafarsa Substation No. 2 near Addis Ababa, 161 KV, double-circuit steel tower with one circuit installed initially, consisting of one overhead ground wire and three 954 MCM ACSR conductors. Average terrain, little clearing. Second circuit to be installed later for Neshe line.	248	kms	50,000.00	12,400,000	(12,400,000)	
	Engineering and General Expense (20±%)						(2,480,000)
4	Gafarsa Substation No. 2--Stage 01 near Addis Ababa. 100,000 KVA, 161/132 KV. Bays Y5, Y6, W1, W2, and W3 complete with autotransformer installation KY5A. See Dwg. No. 4.0-BN-174					(2,950,000)	
	Bay Y5	Lump Sum		Lump Sum	300,000		
	Bay Y6	Lump Sum		Lump Sum	300,000		
	Bay W1	Lump Sum		Lump Sum	250,000		
	Bay W2	Lump Sum		Lump Sum	250,000		
	Bay W3	Lump Sum		Lump Sum	250,000		
	KY5A and appurtenances	Lump Sum		Lump Sum	1,600,000		
	Engineering and General Expense (25±%)						(737,500)
	MISCELLANEOUS JOINT-USE FEATURES					3,325,000	4,156,000
1	Road from top of escarpment down to Irr. Diversion Dam. Two lane, steep mountainous.	20	kms	58,000.00	1,160,000		
2	Permanent camp	Lump Sum		Lump Sum	1,500,000		
	Subtotal				2,660,000		
	Contingencies (25±%)				665,000		
	Field Cost--Misc. Joint-use Features				3,325,000		
	Engineering and General Expense (25±%)				831,000		
	Total est. const. cost--Misc. Joint-use feature.				4,156,000		

TABLE V-1

prices as itemized with unit prices in Table V-1. Electrical facilities, such as the powerplant and transmission plant, were derived from curves based on U. S. Bureau of Reclamation practices and design modified to local conditions. Table V-2 summarizes estimated costs for the various features and includes the estimated allocated cost for the joint-use facilities and the cost of contingencies, engineering, and general expense.

Plan Selection and Alternatives

On the basis of preliminary studies, the plan as selected appeared to be the most feasible economically. The natural falls favored production of hydroelectric power, and the water releases were oriented in this direction rather than toward irrigating more land. The plan as finally selected represents an optimum balance between irrigation and power development.

Alternative damsites were investigated for storage and power diversion. One plan briefly studied included using only one dam for both storage and power diversion, located approximately midway between the falls and the outlet of the swamp. Rough estimates indicated that the combination of the higher dam to store the equivalent amount of water, due to the river slope and the additional length of tunnel for power development, would be more expensive than the two low dams selected.

Visual geological examination of the site precluded the employment of a vertical shaft tunnel and an underground powerplant, which would have been the most economical and desirable solution. Drilling will be required for final determination of plan to evaluate the rock formation. The location of both the tunnel and the penstocks in the selected plan appears to be the more economical alternative.

A higher location of the canals in the project land area was considered, but it was found that locating the canals to serve all of the land classified would mean high construction cost and excessive maintenance problems, since such location would place the canals near the escarpment on steep talus slopes. Some small amount of pumping could be done to reach areas above the gravity canal, but these would be only small scattered areas and were not considered in this study.

TABLE V-2 - ESTIMATED CONSTRUCTION COST SUMMARY
FINCHAA PROJECT

Feature	In thousands of Ethiopian dollars				
	Total construction cost	Joint-use		Total irrigation features	Total power features
		Power	Irrigation		
Finchaa Dam and Reservoir	682	371	311	311	371
Power Diversion Dam	210	---	---	---	210
Power Tunnel and Penstocks	32,948	---	---	---	32,948
Powerplant	11,015	---	---	---	11,015
Transmission Plant	21,004	---	---	---	21,004
Irrigation Diversion Dam	545	---	---	545	---
East Main Canal	3,031	---	---	3,031	---
West Main Canal	1,989	---	---	1,989	---
Distribution System	7,734	---	---	7,734	---
Drains	2,813	---	---	2,813	---
Access Roads	1,813	986	827	827	986
Permanent Camp Facilities	2,343	1,275	1,068	1,068	1,275
Subtotal	86,127	2,632	2,206	18,318	67,809
Development Cost 1/	5,325	---	---	5,325	---
Total Construction Cost	91,452	2,632	2,206	23,643	67,809

1/See SECTION VIII for details.

96

AMARTI-NESHE PROJECT

Plan of Development

The development plan for the multipurpose Amarti-Neshe Project includes two storage dams, a power canal and tunnel, penstocks, powerplant, transmission facilities, irrigation diversion dam, two main canals, a distribution system, and drainage canals to provide irrigation for 8,490 hectares of land and 80,000 kilowatts of power installation.

Storage requirements for the project are to be provided by utilizing the Amarti and Neshe River Basins, connected by an open-ditch channel through a narrow saddle that separates the two basins. The Amarti River channel is almost 42 meters higher in elevation than that of the Neshe and water would be impounded by a low masonry dam that will also serve as a spillway for both reservoirs.

Discharges would be made from the outlet works in the Neshe Dam into a power canal, then to a tunnel and penstocks for production of hydroelectric power. The powerplant would discharge into the Neshe River channel and irrigation water would be diverted by a diversion dam into two main canals for conveyance to the distribution system and farmers' headgates.

The features of the multipurpose project plan are shown in plan on Drawing No. 2.0-Fi-6 and are described in reconnaissance detail in the following paragraphs. Topography of the area was developed in the same manner as on the Finchaa Project area.

Project Features

Amarti-Neshe Dams and Reservoirs

Neshe Dam. The Neshe Dam would be located about 1.3 kilometers upstream from the lip of the falls on the Neshe River. It would be an earth-rockfill dam having a structural height of 60 meters and a crest length of 1,100 meters. Diversion during construction would be accomplished through a gap in the dam, the gap to be closed during the dry season following the completion of the outlet conduit. See Drawing No. OA-23-91 for plan, section, and profile of the Neshe and Amarti Dams.

97

Neshe Dam Data

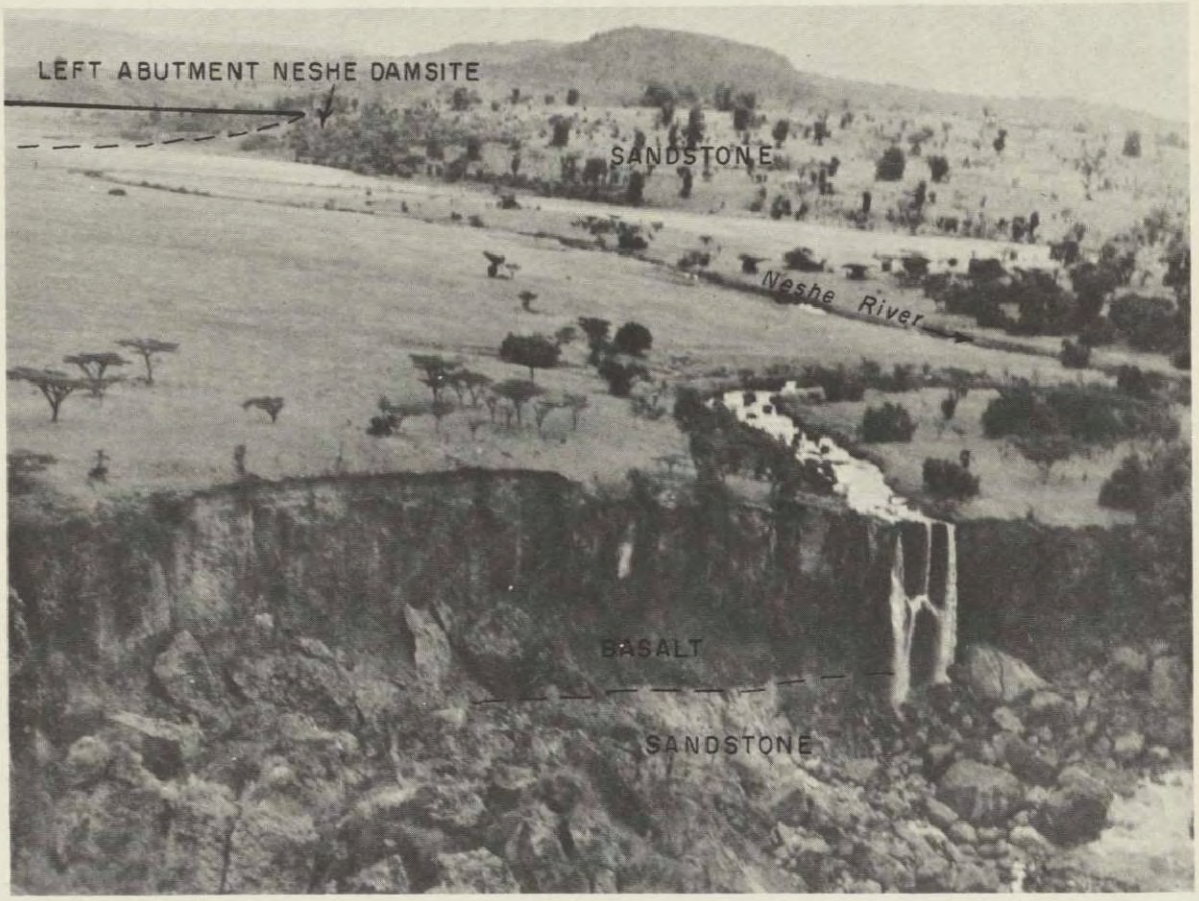
Type	earth-rockfill
Earth embankment, volume	2,300,000 cu. m.
Rock embankment, volume	3,100,000 cu. m.
Elevation of crest	2243 m.
Freeboard	2.41 m.
Structural height	60 m.
Hydraulic height	57.59 m.
Length of crest	1,100 m.
Width of crest	10 m.

Amarti Dam Spillway. By construction of an equalizing channel, the two reservoirs in effect will become one and for hydraulic purposes will be treated as one. The Amarti Dam is planned to serve as a spillway for passing the flood flows for the combined reservoir. Located about five kilometers south of the Neshe Dam and on the Amarti River upstream from the falls, the dam would have a concrete-masonry overflow section abutting a complacted earthfill dike. The spillway section would be 250 meters long with the total earth dike section on both ends of the spillway being 335 meters long. In routing the flood, it was assumed that the reservoir would be full to normal water surface elevation of 2236 meters. With the design inflow flood indicating a peak discharge of 1,939 cubic meters per second and a 2.5-day volume of 116 million cubic meters, the spillway at maximum water surface elevation of 2237.59 meters will discharge 962 cubic meters per second over the ogee concrete crest.

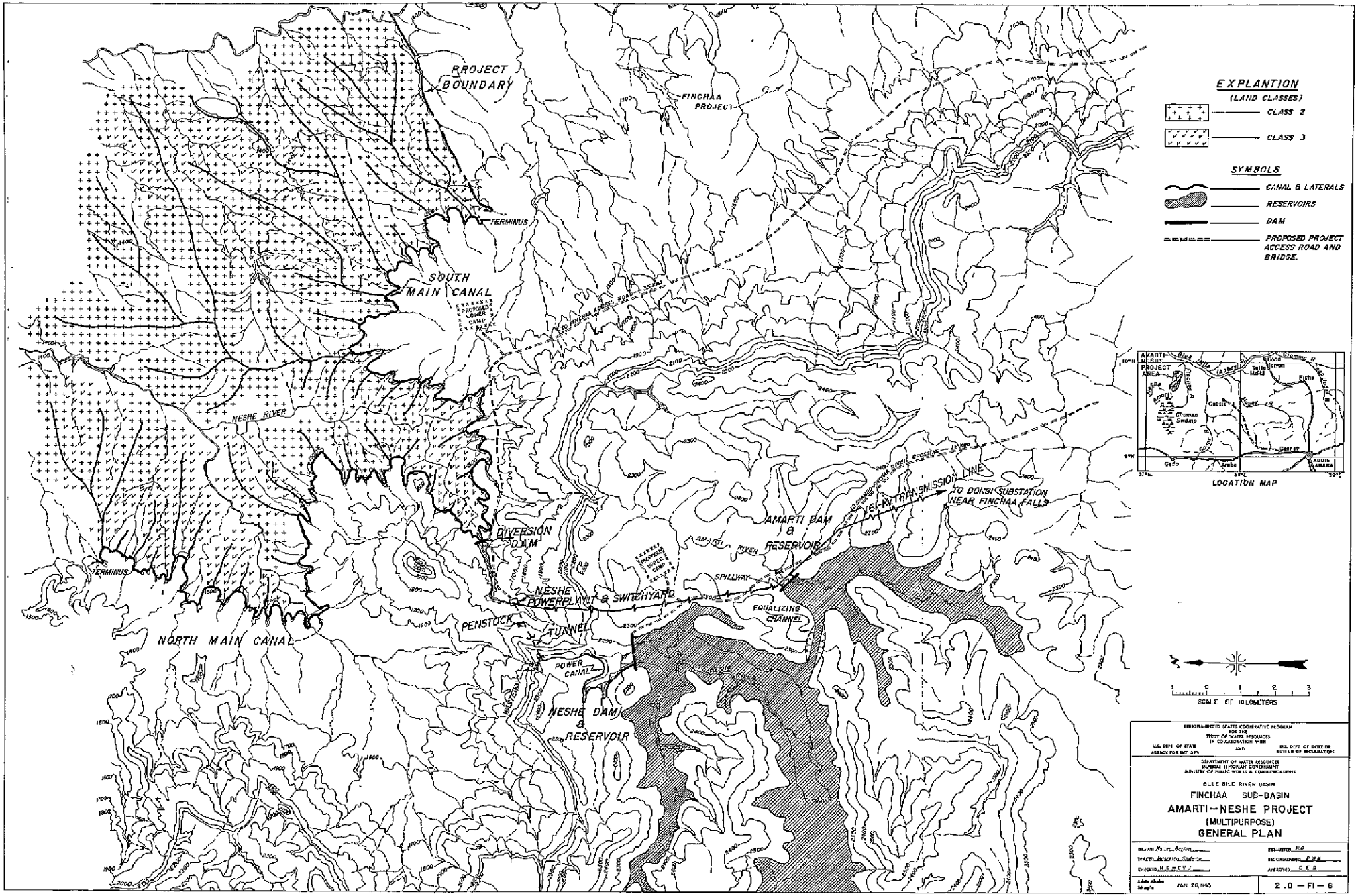
Amarti Dam Spillway Data

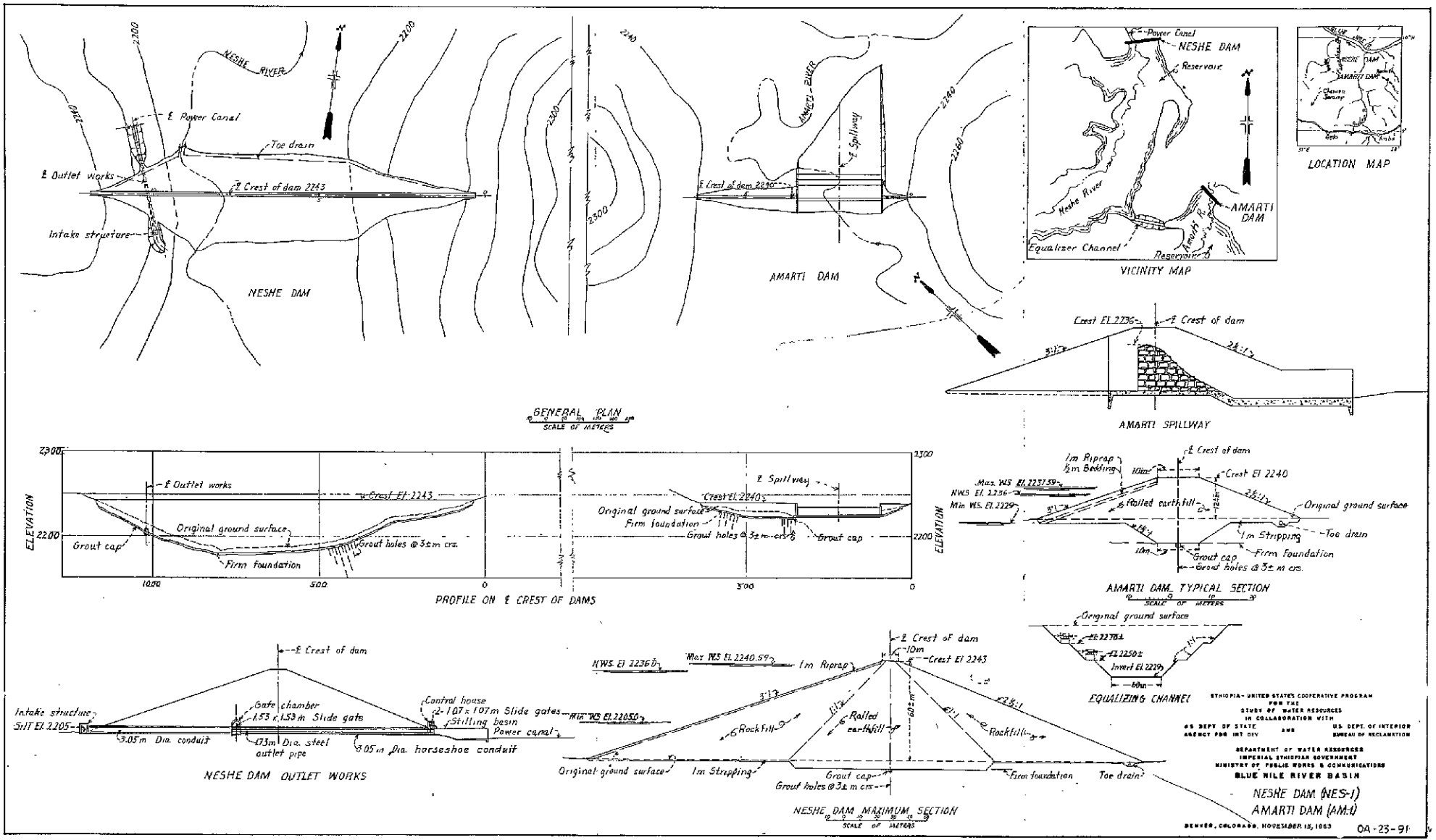
Type	concrete-masonry and earth embankment
Top of dam	2240 m.
Spillway crest elevation	2236 m.
Inflow design flood	1,939 cu. m. per sec.
Volume of concrete and masonry in embankment	53,000 cu. m.
Volume of earth in embankment	170,000 cu. m.
Structural height	15 m.
Hydraulic height	12.59 m.
Length of spillway crest	250 m.
Discharge at maximum w.s. elevation	962 cu. m. per sec.

Neshe Dam Outlet Works. The outlet works would be located on the left abutment of the Neshe Dam. It would consist of an intake structure; a 3.05-meter, horseshoe, concrete conduit under pressure to the gate chamber where a 1.53- by 1.53-meter slide gate is provided for emergency control; and a 1.73-diameter steel outlet pipe from the gate chamber to release water through two metal slide gates discharging into a stilling basin.



NESHE DAMSITE NE-1 & INTERVALLEY BASALT - LOOKING UPSTREAM


PROJECT BOUNDARY
FINCHAA PROJECT
TERMINUS
SOUTH MAIN CANAL
PROPOSED LOWER CAMP
NESHE RIVER
TERMINUS
NORTH MAIN CANAL
DIVERSION DAM
NESHE POWERHOUSE & SWITCHYARD
PENSTOCK
TUNNEL
POWER CANAL
NESHE DAM & RESERVOIR
AMARTI DAM & RESERVOIR
AMARTI RIVER
SPILLWAY
EQUALIZING CHANNEL
16 KM TRANSMISSION LINE
TO DONGI SUBSTATION NEAR FINCHAA FALLS
EXPLANTION
(LAND CLASSES)
CLASS 2
CLASS 3
SYMBOLS
CANAL & LATERALS
RESERVOIRS
DAM
PROPOSED PROJECT ACCESS ROAD AND BRIDGE.
LOCATION MAP
SCALE OF KILOMETERS
ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH JAIC
U.S. DEPT OF STATE AGENCY FOR INT. DEV.
U.S. DEPT OF INTERIOR BUREAU OF RECLAMATION
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN
FINCHAA SUB-BASIN
AMARTI--NESHE PROJECT
(MULTIPURPOSE)
GENERAL PLAN
DRAWN Water Section
TRACED Mengistu Sahlu
CHECKED H.E. & G.V.J.
SUBMITTED H.G.
RECOMMENDED D.P.M.
APPROVED C.E.B.
Addis Ababa Mar's JAN 20, 1963
2.0 — FI — 6


NESHE RIVER
℄ Power Canal
Toe drain
℄ Outlet works
℄ Crest of dam 2243
Intake structure
NESHE DAM
AMARTI RIVER
℄ Spillway
℄ Crest of dam 2230
AMARTI DAM
GENERAL PLAN
SCALE OF METERS
Power Canal
NESHE DAM
Reservoir
Neshe River
AMARTI DAM
Equalizer Channel
Reservoir
VICINITY MAP
LOCATION MAP
Crest El 2236
℄ Crest of dam
AMARTI SPILLWAY
ELEVATION
℄ Outlet works
Crest El 2243
Original ground surface
Grout cap
Firm foundation
Grout holes @ 3± m crs.
℄ Spillway
Crest El 2240
Firm foundation
Grout cap
PROFILE ON ℄ CREST OF DAMS
1m Riprap
½m Bedding
Max WS El 2237.59
NWS El 2236
Min WS El 2229
℄ Crest of dam
Crest El 2240
Rolled earthfill
Original ground surface
1m Stripping
Toe drain
Grout cap
Firm Foundation
Grout holes @ 3± m crs.
AMARTI DAM TYPICAL SECTION
SCALE OF METERS
Original ground surface
EQUALIZING CHANNEL
℄ Crest of dam
Intake structure
Silt El 2205
Gate chamber
1.53 x 1.53 m Slide gate
Control house
2-1.07 x 1.07 m Slide gates
Stilling basin
Power canal
3.05 m Dia. conduit
1.73 m Dia. steel outlet pipe
3.05 m Dia. horseshoe conduit
NESHE DAM OUTLET WORKS
NWS El 2236
Max WS El 2240.59
1m Riprap
℄ Crest of dam
Crest El 2243
Min WS El 2205.0
Rolled earthfill
Rockfill
Original ground surface
1m Stripping
Grout cap
Grout holes @ 3± m crs.
Firm foundation
Toe drain
NESHE DAM MAXIMUM SECTION
SCALE OF METERS
ETHIOPIA - UNITED STATES COOPERATIVE PROGRAM
FOR THE
STUDY OF WATER RESOURCES
IN COLLABORATION WITH
U.S. DEPT. OF STATE
AGENCY FOR INT DEV
AND
U.S. DEPT. OF INTERIOR
BUREAU OF RECLAMATION
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN
NESHE DAM (NES-1)
AMARTI DAM (AM-1)
DENVER, COLORADO, NOVEMBER 15, 1963
OA-23-91

Outlet Works Data

Sill elevation	2205 m.
Capacity at w.s. elev. 2214.89	20 cu. m. per sec.
Type of gate	slide gates

Reservoirs. Both the Amarti and the Neshe Basins are covered with clay, forming an excellent impermeable blanket. Seepage is not considered a serious problem. The wide, flat-bottomed, grassland valleys are underlain by a thin flow of younger basaltic lava which has prevented rapid downward erosion. The reservoir at normal water surface elevation would impound 847 million cubic meters of water covering an area of 53 square kilometers. Reservoir data are shown on Drawings Nos. 2.2-BN-3 and -4; the area-capacity curve is shown on Drawing No. 2.0-Fi-14, including sediment disposition.

Site Geology

Amarti-Neshe Damsites. The upstream drainage area and source of the water supply for the Amarti-Neshe projects originates on the high plateau of Adigrat sandstone capped by volcanic rock. On the lower portion of the plateau only isolated remnants of the volcanic materials remain. Younger volcanic rock occupies the lower portion of previously eroded stream channels and, being harder than the sandstone, maintains vertical waterfalls at the brink of the plateau, thus retarding downward erosion on the plateau. The plateau streams meander through gently sloping grassland meadows with poorly defined stream channels. Exposures of basalt at the waterfalls range from three to ten meters thick, but it is anticipated that at the proposed dam axis upstream the basalt cover may be much thinner. Due to the soil cover and the heavy growth of swamp grass, the intervalley flow of basalt is not exposed. The ridges forming the abutments for the proposed dams are composed of sandstone.

The plateau breaks sharply several hundred meters below to gently sloping project lands that could be supplied with water for irrigation after its passage through the hydroelectric powerplant. Reservoir storage would be provided on the plateau by constructing dams on both the Amarti and the Neshe Rivers. The reservoirs would be operated as a single unit by excavating an interconnecting channel between the two reservoirs; thus, only one spillway would be required, probably at the Amarti Dam. The interconnecting channel is in sandstone, and no doubt most of the excavated material can be used as borrow material for constructing the Neshe earthfill dam. The Amarti Dam would probably be a concrete or masonry structure in order to provide a weir type spillway over the dam.

The power canal would be in sandstone, as would the tunnel and penstock leading to the Neshe powerplant located at the base of the plateau. The foundation material for the Neshe powerplant is sandstone. No difficult foundation problems are anticipated.

The small diversion dam to be located downstream from the Neshe powerplant would be founded on sandstone. From this diversion dam, a North Main Canal and a South Main Canal would transport water to project lands located on both sides of the river. Most of the project land is of deep alluvial and slopewash soil underlain by sandstone, except that there is metamorphic rock in the lower portion of the project area.

The damsites on the Neshe and Amarti Rivers are very similar, and geologic conditions are essentially identical. The wide, flat bottomed, grassland valleys are underlain by a thin flow of "younger" basaltic lava which has prevented rapid downward erosion. The stream meanders over the grassy meadow in a shallow, hardly recognizable, stream channel on a clayey soil blanket. Only at the falls at the brink of the plateau is the basalt exposed. At the falls, the basalt is up to ten meters thick. The clay blanket is estimated to be from two to five meters thick at the damsites. Beneath the clay blanket the abutments are Adigrat sandstone.

A core drill exploration program would be required to determine excavation depths to the volcanic rock in order to obtain a satisfactory foundation for a concrete or masonry dam. The need for a grout curtain should be anticipated. However, the clay blanket should alleviate excessive leakage from the reservoir.

The cutoff trench for the earthfill dam should extend into the volcanic rock, and a grout curtain is needed along the cutoff trench to assure against leakage.

For reconnaissance designs, cutoff excavations are estimated at an average depth of five meters for both the stream channel section and the abutments.

Construction Materials

Impervious construction materials are available on the slopes and ridges near the damsites and from the interconnecting channel excavations. Riprap and rockfill can be obtained from the intervalley basaltic lava upstream or downstream from the damsites. Volcanic material can also be crushed for concrete aggregate.

103

AMARTI DAMSITE AM-I - LOOKING DOWNSTREAM

NESHE (w/o Amarti) DAM & RESERVOIR

AREA CAPACITY DATA
(with sediment distributed)

CONTROL POINTS				INITIAL AREA (SQ. METERS – 10^6)	CAPACITY (CUBIC METERS – 10^6)			
ITEM & ALLOCATION OF STORAGE CAPACITY		DIAGRAM OF DAM	ELEVATION (METERS)		INITIAL		WITH 50-YR. SEDIMENT	
					INCREMENT	TOTAL	INCREMENT	TOTAL
TOP OF DAM			2243.00					
MAXIMUM W.S.	FREEBOARD		2240.59	32.7		878.9		868.4
NORMAL W. S.	FLOOD SURCHARGE		2236.00	30.6	143.8	735.1	143.8	724.6
	ACTIVE CAPACITY		2214.89	17.0	507.0	228.1	502.9	221.7
MINIMUM OPERATING W.S. LIP OF LOWEST OUTLET*	INACTIVE CAPACITY		2205.00	9.8	133.1	95.0	131.1	90.6
	DEAD STORAGE AND SILT				95.0		90.6	
STREAM BED			2183.00	0		0		0

*100-YEAR SEDIMENT OF 21 x 10^6 M^3 WILL TAKE 2184.3 METERS ELEVATION AT THE DAM.

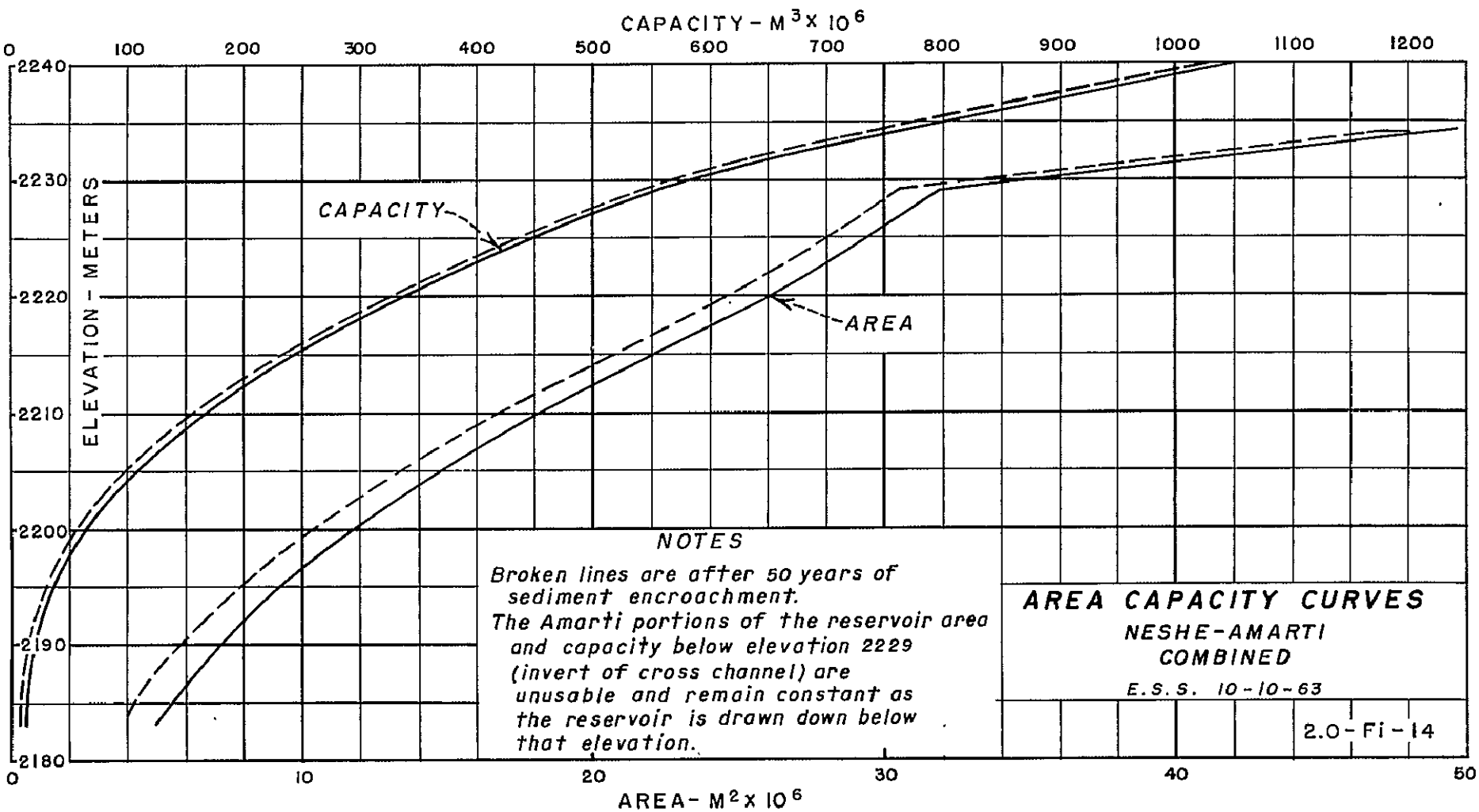
AMARTI DAM & RESERVOIR

AREA CAPACITY DATA

(with sediment distributed)

CONTROL POINTS: ITEM & ALLOCATION OF STORAGE CAPACITY		DIAGRAM OF DAM	ELEVATION (METERS)	INITIAL AREA (SQ. METERS – 10^6)	CAPACITY (CUBIC METERS – 10^6): INITIAL INCREMENT	INITIAL TOTAL	WITH 50-YR. SEDIMENT INCREMENT	WITH 50-YR. SEDIMENT TOTAL
TOP OF DAM			2240.00					
MAXIMUM W.S.	FREEBOARD		2237.59	25.0		142.9		132.4
NORMAL W.S.	FLOOD SURCHARGE		2236.00	22.8	30.4	112.5	30.4	102.0
	ACTIVE CAPACITY				99.9		93.9	
MINIMUM OPERATING W.S.			2229.00	5.0		12.6		8.1
LIP OF LOWEST OUTLET*	INACTIVE CAPACITY		2229.00	5.0	0	12.6	0	8.1
	DEAD STORAGE AND SILT				12.6		8.1	
STREAM BED			2225.00	0		0		0

*100-YEAR SEDIMENT OF 21 x 10^6 M^3 WILL TAKE 2228.6 METERS ELEVATION AT THE DAM.



NOTES

Broken lines are after 50 years of sediment encroachment.
The Amarti portions of the reservoir area and capacity below elevation 2229 (invert of cross channel) are unusable and remain constant as the reservoir is drawn down below that elevation.

AREA CAPACITY CURVES

NESHE-AMARTI COMBINED

E.S.S. 10-10-63

2.0-Fi-14

The geology is shown on General Geology Reconnaissance Map No. 14, Drawing No. 5.2-Fi-2 (SECTION IV). Geologic sections for the Neshe and Amarti damsites are shown on Drawings Nos. 2.0-Fi-7 and 2.0-Fi-8. The general plan of the Amarti-Neshe Project is shown on Drawing No. 2.0-Fi-6.

Access to Sites

Access to the potential damsites will have to traverse rolling country from the Finchaa River road crossing. This will require construction of an access road for a distance of approximately 12 kilometers with one major river crossing, that of the Amarti River. Access to the powerplant could be made from the proposed Finchaa access road and would require building a road 35 kilometers in length through hilly country. This same road would serve as an access to the project lands.

Power Canal

The power canal conveys the water from the Neshe Dam to the forebay at the tunnel, which in turn supplies the powerplant through penstocks. The canal is about six kilometers long and is designed to supply water to the tunnel at approximately 20 cubic meters per second. Masonry lining for the canal has been provided for. Some forebay storage is necessary, but, due to the fact that the forebay is located close to the edge of the escarpment, the size of the pool may be restricted. With the canal capacity at 20 cubic meters per second, about 5,500 cubic meters of forebay storage to meet daily regulation requirements are indicated. This will require scheduling water releases to the canal from the outlet works to meet anticipated load requirements. Water surface elevations in the canal would be held nearly constant with all but minor fluctuations avoided.

Power Tunnel and Penstocks

The tunnel would be pressure type to withstand the high head. At the beginning, it would be reinforced-concrete lined, but it would require an encased steel pipe at the lower end. It would be about 433 meters long with a diameter of 2.40 meters.

Two welded steel penstocks would be required at the outlet end of the tunnel with butterfly valves for emergency controls. The penstocks would be 1.52 meters in diameter and 1,467 meters long. The thickness would vary from 27 millimeters at the beginning to about 50 millimeters near the end.

Tunnel Data

Type	pressure
Length	433 m.
Diameter	2.40 m.
Design capacity 1/	18.2 cu. m. per sec.

Penstock Data

Type (2 each)	welded steel
Length (each)	1,467 m.
Diameter (each)	1.52 m.
Design capacity (each) 1/	9.1 cu. m. per sec.

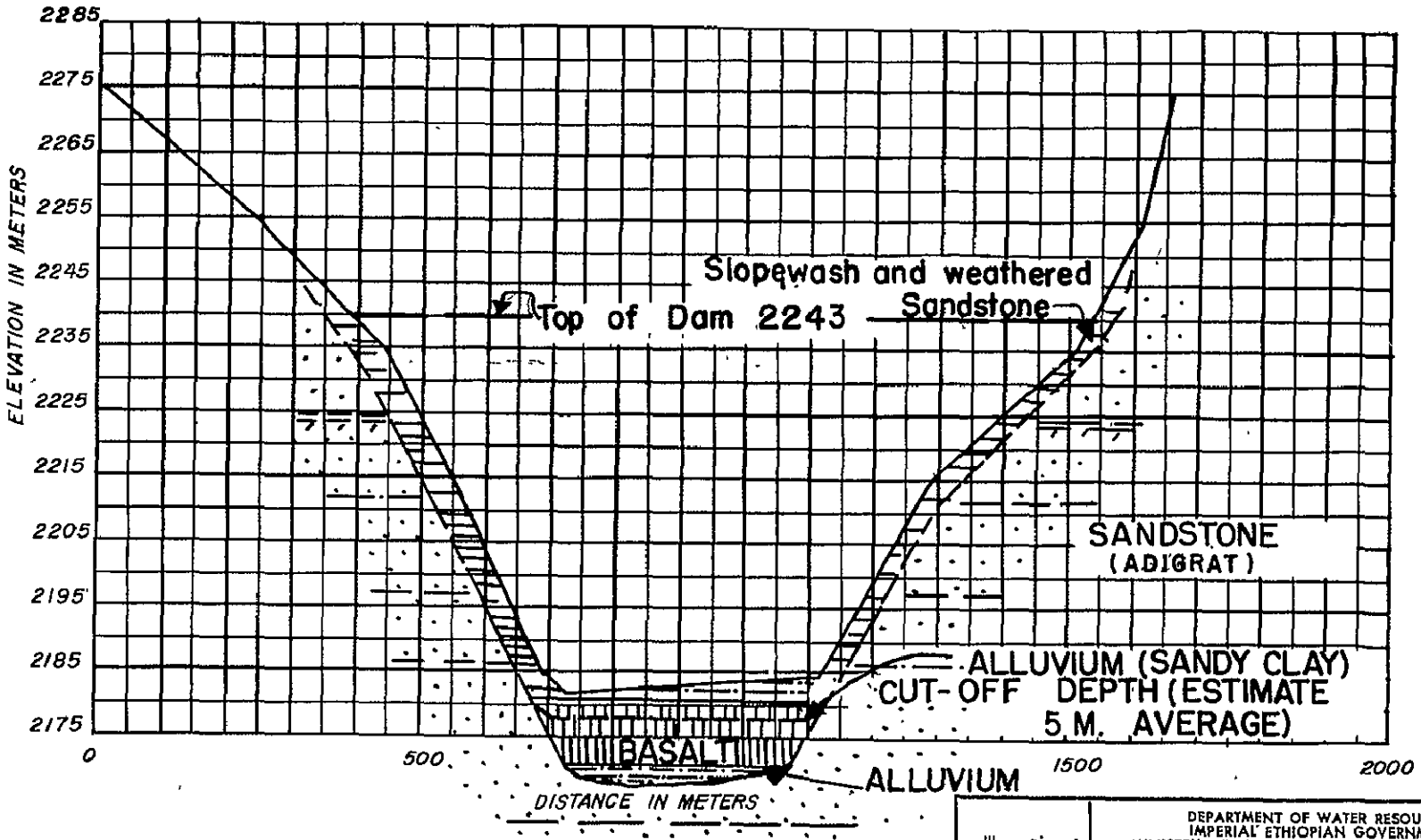
Powerplant

Conveyance of water from the forebay to the powerplant turbines would be by pressure tunnel and welded steel penstock. According to operation studies made (SECTION III), the annual gross generation would be 378,000,000 kilowatt-hours for an adverse water supply period. Two generator units of 40 mw. each would be satisfactory, providing a total plant capacity of 80 mw. or 100 mv.-a. at 0.8 power factor.

Due to the high head, 560 meters (net), the two turbines will be of the impulse-type, each rated 55,725 metric hp. (56,500 English hp.), and could be double-runner with a single jet per runner, all very similar to the Finchaa powerplant installation. Horizontal shaft, double-overhung, single-nozzle, 375-r.p.m. wheels would be adequate. The flow of water to the turbines would be controlled by a needle valve from governor action related to load demand, and the governor would also simultaneously operate a pressure regulator to by-pass water from the penstock, during load surges, to the tailrace. Energy absorbers are required to dissipate water from the pressure regulators.

The two generators would have individual step-up transformers, as shown by Drawing No. 4.0-BN-87, from 13.8-kv. generator voltage to 161-kv. transmission voltage, each transformer rated 50,000 kv.-a. Certain powerplant components have been made identical with the Finchaa powerplant so as to ease the operation and maintenance problems and to reduce the investment in spare parts. The switchyard arrangement is identical to that shown for the Finchaa powerplant.

1/Peaking capacity has been included in these facilities. They are adequate to supply water to the powerplant, permitting the generators to meet expected normal load requirements initially, with future use for possible peaking operation.



DIAGRAMMATIC GEOLOGIC SECTION

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF STAGEN. FOR INT DEV. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

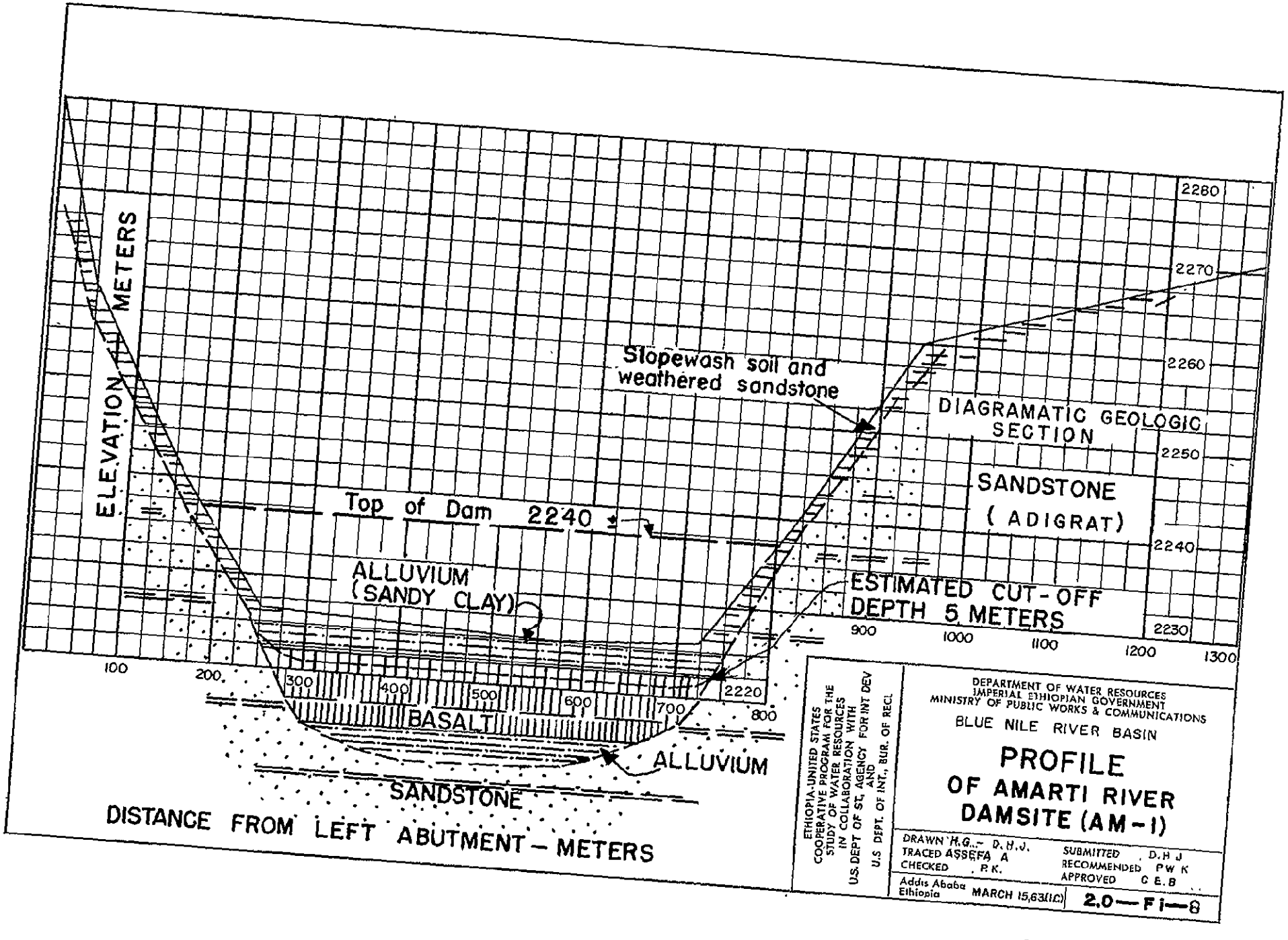
PROFILE

NESHE RIVER DAM SITE (NES-1)

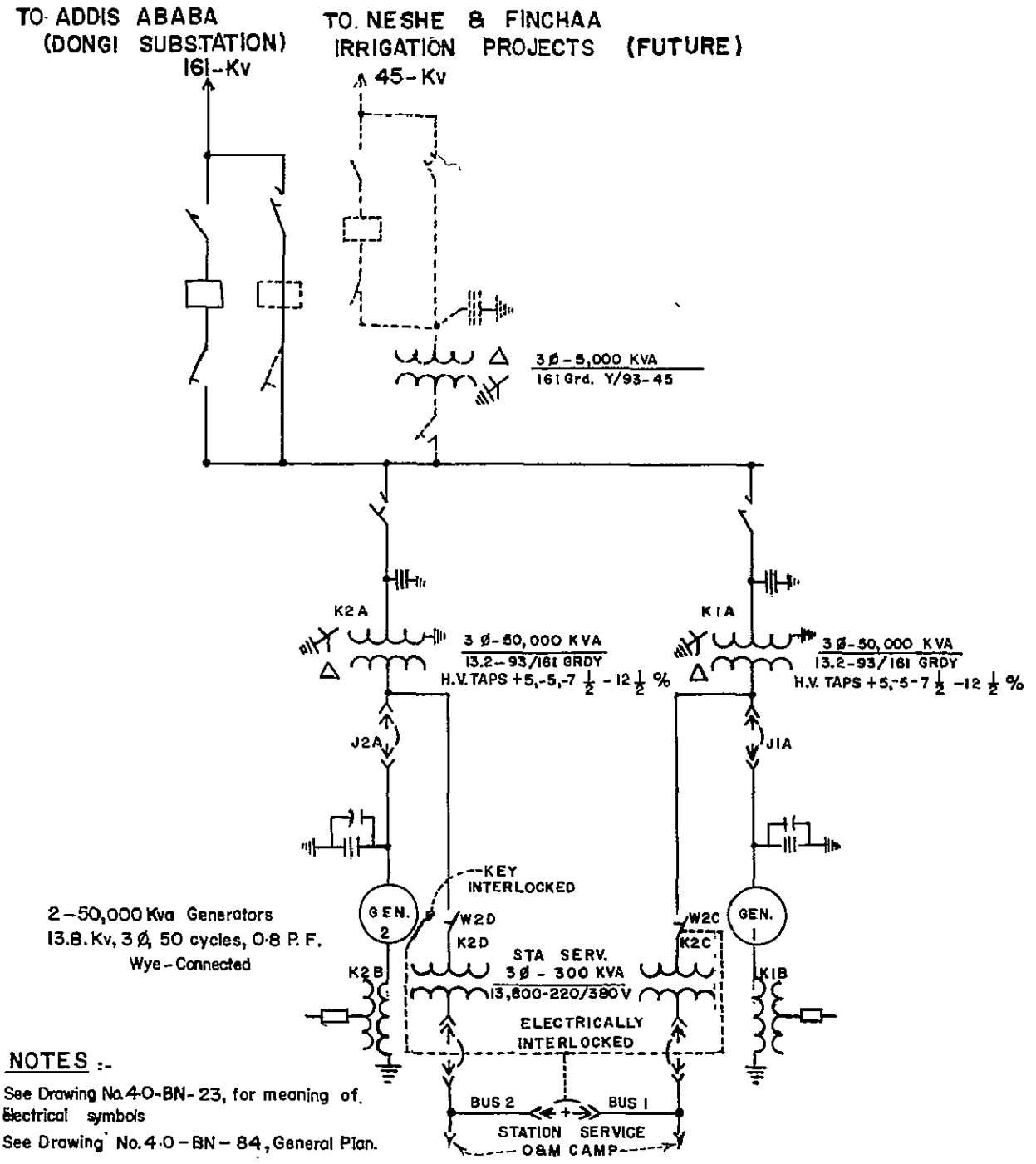
DRAWN H.G – G.G. ... SUBMITTED Q.H.J.
TRACED Getachew...Zewdie. RECOMMENDED P.W.K.
CHECKED G.L.G.– Q.H.J. APPROVED C.E.B.

Addis Ababa, Ethiopia. March 14, 1963 | 20-Fi-7

110


ELEVATION IN METERS
2280
2270
2260
2250
2240
2230
Slopewash soil and weathered sandstone
DIAGRAMATIC GEOLOGIC SECTION
SANDSTONE (ADIGRAT)
Top of Dam 2240 ±
ALLUVIUM (SANDY CLAY)
ESTIMATED CUT-OFF DEPTH 5 METERS
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
2220
BASALT
ALLUVIUM
SANDSTONE
DISTANCE FROM LEFT ABUTMENT – METERS
ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT OF ST, AGENCY FOR INT DEV AND U.S. DEPT. OF INT., BUR. OF RECL
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN
PROFILE OF AMARTI RIVER DAMSITE (AM-1)
DRAWN H.G. D.H.J.
TRACED ASSEFA A
CHECKED P.K.
SUBMITTED D.H.J
RECOMMENDED P.W.K
APPROVED C.E.B
Addis Ababa Ethiopia
MARCH 15,63(I.C)
2.0—Fi—8

14



NOTES :-

1. See Drawing No. 4-0-BN-23, for meaning of Electrical symbols
2. See Drawing No. 4·0-BN-84, General Plan.
3. For location Dongi Substation, See Drawing No. 4·0-Fi-13.
4. Elevation 1625 meters.

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., AGEN. FOR INT. DEV. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN

SWITCHING DIAGRAM
NESHE RIVER POWERPLANT
NESHE RIVER FALLS

DRAWN. C.L.C. SUBMITTED. C.L.C.
TRACED Gebre Christos RECOMMENDED P.W.K.
CHECKED C.L.C. - G.V.J. APPROVED C.E.B.

Addis Ababa Jan. 1963.
Ethiopia

4·0-BN-87

112

Summarizing, the generators would have the general characteristics shown below.

Speed	375 r.p.m.
Number of poles	16
Horizontal shaft, direct connected	
Voltage, wye connected	13.8 kv.
Frequency	50 cycles
Power factor, variable, 0.8 thru unity, lag or lead	

Transmission Plant

Transmission Lines. See the discussion for the Finchaa powerplant. A single-circuit, steel tower, 954-MCM ACSR conductor, transmission line will be required from Neshe powerplant to the site of the Dongi Substation on the escarpment very near the Finchaa power diversion dam above the Finchaa powerplant (Dwgs. Nos. 2.0-Fi-2 and -6), a distance of about 32 kilometers. From the Dongi Substation to Addis Ababa it will be necessary to install only the three, 954-MCM ASCR conductors on one side of the existing double-circuit steel tower line.

Substations. The Dongi Substation (see Dwg. No. 2.0-Fi-2) will initially be a switching station so as to provide for some flexibility in operation and maintenance. However, it will not be required until the Neshe power facilities are constructed, and at that time the single-circuit 161-kv. line (32 km.) from Neshe and the 161-kv. single-circuit line (1.8 km.) from Finchaa will terminate at the Dongi Substation. Also terminating at the Dongi Substation will be the 248-km., 161-kv., double-circuit line to Addis Ababa, as previously discussed. Prior to the construction of Neshe there will be about 249.8 km. of 161-kv. line, consisting of 1.8 km. of single-circuit tower construction and 248 km. of double-circuit tower construction carrying one circuit, in operation.

Stage 02 in the receiving-end substation at Addis Ababa to provide proper terminal facilities for the second 161-kv transmission circuit from Neshe will be needed. See discussions on substations, Finchaa Project. Stage 02 in Gafarsa Substation No. 2 is shown on Drawing No. 4.0-BN-174 and will consist of a line bay and a transfer bay in the 161-kv. yard as well as a second 161/132-kv. autotransformer bank, KY3A, to parallel the first autotransformer bank, KY5A. In addition, another 132-kv. line bay position and a 132-kv. transfer bay are necessary, all as explained by Note 2 on Drawing No. 4.0-BN-174.

W3

The reactive control facilities, consisting essentially of two synchronous condensers, may not be required at the time the Neshe facilities are placed into operation, all depending upon the reactive support obtained from the Awash plants. However, with both plants delivering full output on peak to the Addis Ababa area, and receiving no reactive support at the receiving-end terminal, the synchronous condenser installation will be required. For light load conditions, either shunt reactors or synchronous condensers operated lagging may be needed. Synchronous condenser installations made early enough could provide for the light load requirements initially and also provide for the heavy load reactive support later. During the feasibility stage of investigations more data will be available regarding the Awash machine characteristics and load characteristics, including the reactive problem at principal load centers. For this study, the added cost of the synchronous condensers will be included, recognizing that an installation of the size shown may or may not be required, depending upon the factors noted above.

Irrigation Diversion Dam

The dam would be located a short distance upstream from the confluence of the Amarti and Neshe Rivers. It would divert the flows from the discharges of the powerplant into the two main canals for irrigation purposes. Because the flood flows are passed through the Amarti Dam spillway and thence into the Amarti River, the possible flood flows at the diversion dam were found to be negligible. The diversion dam is envisioned as an overflow, masonry-concrete dam with suitable outlet and sluice works provided.

Irrigation Diversion Dam Data

Volume of masonry	1,850 cu. m.
Normal water surface elevation	1,501.5 m.
Structural height	5.0 m.
Crest length of spillway	60.0 m.
Length of dam	83.0 m.

Main Canals

Since they are part of the larger Finchaa valley, the descriptive narrative included in the Finchaa Project would apply. Two main canals are also planned for this project to convey the water to the land.

South Main Canal. The South Main Canal would extend in an easterly direction for about 39 kilometers. It would originate at the discharge end of the outlet works on the right abutment of the diversion dam. The canal would be open and unlined, with an initial

114

capacity of 11.65 cubic meters per second. It would traverse innumerable draws and ravines, requiring suitable structures to accommodate the high flows of the rainy reason. Canal excavation will not present any major problems, but rock will probably be encountered in a few isolated reaches. The canal is designed to serve by gravity 6,360 hectares of irrigable lands.

South Main Canal Data

Length	39 km.
Type	unlined
Initial capacity	11.65 cu. m. per sec.
Initial w.s. elevation	1500 m.

North Main Canal. The North Main Canal would extend in a northerly direction for about 29.4 kilometers. It would originate at the discharge end of the outlet works on the left abutment of the diversion dam. The canal would have an initial capacity of 3.5 cubic meters per second designed to serve approximately 2,130 hectares of land.

North Main Canal Data

Length	29.4 km.
Type	unlined
Initial capacity	3.5 cu. m. per sec.
Initial w.s. elevation	1500 m.

Distribution System and Drains

The distribution system and surface drainage requirements are similar to those of the Finchaa Project, and costs of these items have been estimated at Eth$330 and Eth$120 per hectare, respectively, excluding contingencies, engineering, and general expense.

Service Facilities

Service facilities will be required for construction and later for operation and maintenance of the project features. Cost for this item has been estimated on the same basis as for Finchaa Project.

Estimates of Construction Cost

The construction cost for the multipurpose Amarti-Neshe Project is estimated at Eth$123,020,000 on the basis of January 1961 prices as itemized with unit prices on Table V-3. Electrical facilities,

such as the powerplant and transmission plant, were derived from curves based on U. S. Bureau of Reclamation practices and design modified to local conditions. Table V-4 summarizes estimates for the various features and includes the estimated allocated cost for the joint-use facilities and the cost for contingencies, engineering, and general expense.

Plan Selection and Alternatives

The plan of development proposed, as in the case of the Finchaa Project, was to utilize to its maximum the power head available, with irrigation as a secondary objective, inasmuch as hydrologic studies indicated that there was an abundance of water for irrigation.

Alternative plans studied included a plan to divert the Amarti River into the Chomen Swamp. However, the cost of the larger cut to divert the stream and the fact that the Neshe River could not be utilized, since the stream is 35 meters lower than the Amarti, made the plan unattractive.

A plan was considered to produce power from the Amarti Dam and Reservoir rather than from the Neshe, due to the slightly higher head available. However, because of the difference in elevation of the two reservoirs, it was found that much of the Neshe storage would be inactive.

Operation studies indicate that the two reservoirs will produce approximately twice the amount of water required for irrigation for the 8,490 hectares of land. Further land classification studies will be needed to determine if additional land can be made available.

Similar geological conditions as those applying to the Finchaa Project precluded the employment of an underground powerplant. The plan selected under these circumstances appeared to be the most economical and feasible.

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN-ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project AMARTI-NESHE--Multiple-purpose

Date of Estimate November 1963 — Currency in terms of Ethiopian Dollars

Prices as of January 1961 — (U.S. $ 1.00 = Eth. $ 2.50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	POWER CANAL --Capacity, 20 m^3/sec; length 6,000 meters from stilling basin [illegible] Dam to tunnel inlet, including fore-bay storage. Lined					1,770,300	2,213,000
1	Canal excavation, common	105,410	m^3	0.82	86,436		
2	Canal excavation, rock	26,400	m^3	8.00	211,200		
3	Parallel drain excavation, common	3,000	m^3	0.82	2,460		
4	Grouted rubble paved waterway	66,252	m^2	15.00	993,780		
	Terminal Structure						
5	Excavation for structure, common	720	m^3	4.00	2,880		
6	Excavation for structure, rock	180	m^3	8.00	1,440		
7	Excavation for wasteway channel, some rock	1,800	m^3	3.50	6,300		
8	Concrete, structural	104	m^3	210.00	21,840		
9	Concrete, in slabs	49	m^3	150.00	7,350		
10	Grouted rubble paved waterway	140	m^2	15.00	2,100		
11	Reinforcement steel	6,900	kgs	1.00	6,900		
12	Radial gates and hoists						
	4 - 2.00 x 2.00 meter	4,000	kgs	5.50	22,000		
	2 - 2.00 x 6.40 meter	7,300	kgs	5.50	40,150		
13	Trashrack and misc. metal work	3,200	kgs	2.60	8,320		
14	Fence, 2 meter chainlink with 3 m gate	80	lm	39.20	3,136		
	Subtotal				1,416,292		
	Contingencies (25±%)				354,008		
	Field Cost -- Power Canal				1,770,300		
	Engineering and General Expense (25±%)				442,700		
	Total est. construction cost--Power Canal				2,213,000		
	POWER TUNNEL -- Concrete lined pressure tunnel, 433 meters long; diameter, 2.40 meters; max. head, 200 meters					1,957,300	2,251,000
1	Excavation, tunnel	2,685	m^3	158.00	424,230		
2	Concrete in tunnel lining	730	m^3	238.00	173,740		
3	Tunnel supports and lagging	Lump sum		L.S	98,500		
4	Reinforcement steel	120,300	kgs	1.12	134,736		
5	Incased steel pipe	196,850	kgs	3.43	674,167		
6	Grouting and drainage	Lump sum		L.S.	60,500		
	Subtotal				1,565,873		
	Contingencies (25±%)				391,427		
	Field cost -- Power Tunnel				1,957,300		
	Engineering and General Expense (15-±%)				293,700		
	Total est. const. cost -- Power Tunnel				2,251,000		
	IRRIGATION CANALS -- Unlined					2,378,200	2,973,000
	South Main Canal and laterals over 1.0 m^3/sec -- length, 39.0 kms; capacity, 11.65 to 2.24 m^3/sec.					(1,595,300)	(1,994,000)
1	Canal excavation, common	319,300	m^3	0.82	261,826		
2	Canal excavation, rock	35,500	m^3	8.00	284,000		
3	Compacting embankment	91,620	m^3	0.98	89,788		
4	Structures	Lump sum		L.S.	539,000		
5	Gates, hoists, values and misc. metalwork	Lump sum		L.S.	12,700		
6	Concrete pipe	Lump sum		L.S.	25,400		
7	Other miscellaneous work	Lump sum		L.S.	63,500		
	Subtotal				1,276,214		
	Contingencies (25±%)				319,086		
	Field Cost -- South Main Canal				1,595,300		
	Engineering and General Expense (25±%)				398,700		
	Total est. const. cost -- South Main Canal				1,994,000		

TABLE V-3

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN—ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project: AMARTI-NESHE--Multiple-purpose

Date of Estimate: November 1963

Currency in terms of Ethiopian Dollars

Prices as of: January 1961

(U.S. $ 1.00 = Eth. $ 2.50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	AMARTI Dam--Earthfill; max. height, 12 meters; crest length, 375 meters. Dwg. No. OA-23-91						
	Joint-use.					10,222,800	12,267,000
1	Diversion and care of river	Lump sum		Lump sum	41,000		
2	Excavation, stripping borrow pits	9,400	m^3	1.15	10,810		
3	Excavation, all classes, dam foundation	42,000	m^3	1.95	81,900		
4	Excavation, rock, for grout cap	400	m^3	80.00	32,000		
5	Excavation, common, in borrow areas and transportation to embankment	190,000	m^3	2.75	522,500		
6	Earthfill in embankment	170,000	m^3	0.65	110,500		
7	Riprap on upstream slope of embankment	12,000	m^3	11.00	132,000		
8	Bedding for riprap on embankment	6,000		15.00	90,000		
9	Pressure grouting, all work and material	Lump sum		Lump sum	183,000		
10	Furnishing and constructing 20 cm conc. pipe toe drains with open joints	300	lm	21.00	6,300		
	Spillway--Concrete ogee crest 250 meters long. Capacity, 962 m^3/sec.						
11	Excavation, all classes, open cut	105,000	m^3	3.25	341,250		
12	Concrete--inlet and crest walls	1,850	m^3	210.00	388,500		
13	Masonry--crest structure	36,900	m^3	70.00	2,583,000		
14	Concrete--Stilling basin	14,300	m^3	150.00	2,145,000		
15	Reinforcement	877,000	kg	1.00	877,000		
16	Minor items, misc. metalwork, etc.	Lump sum		Lump sum	633,500		
	Subtotal				8,178,260		
	Contingencies (25±%)				2,044,540		
	Field cost--Amarti Dam				10,222,800		
	Engineering and General Expense (20±%)				2,044,200		
	Total est. const. cost--Amarti Dam				12,267,000		
	IRRIGATION DIVERSION DAM--Stone masonry dam with 60 meter ogee spillway; crest length, 83 meters; max. height, 5 meters					233,400	280,000
1	Diversion and care of river	Lump sum		Lump sum	8,500		
2	Excavation, common for weir and structures	2,500	m^3	1.95	4,875		
3	Excavation, rock for weir and structures	1,000	m^3	8.00	8,000		
4	Masonry in weir and abutments	1,850	m^3	70.00	129,500		
5	Concrete in headworks and sluiceways	95	m^3	210.00	19,950		
6	Pressure grouting foundations	83	lm	83.00	6,889		
7	Gates, gate hoists, handrails and etc.	Lump sum		Lump sum	9,000		
	Subtotal				186,714		
	Contingencies (25±%)				46,686		
	Field cost--Irr. Diversion Dam				233,400		
	Engineering and General Expense (20±%)				46,600		
	Total est. const. cost--Irr. Diversion Dam				280,000		

TABLE V-3

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN—ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project: AMARTI-NESHE--Multiple-purpose

Date of Estimate: November 1963

Currency in terms of Ethiopian Dollars

Prices as of: January 1961

(U.S. $ 1.00 = Eth. $ 2.50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	AMARTI-NESHE--Multiple-purpose					100,762,400	123,020,000
	Joint-use features					(47,545,000)	(57,259,000)
	Power features					(45,617,900)	(56,274,000)
	Irrigation features					(7,599,500)	(9,487,000)
	NESHE DAM--Earthfill; max. height, 60 meters; crest length, 1150 meters; spillway at Amarti Dam. Dwg. No. OA-23-91. Joint-use.					33,222,200	39,867,000
1	Diversion and care of river	Lump sum		Lump sum	52,000		
2	Excavation, stripping borrow pits	130,000	m^3	1.15	149,500		
3	Excavation, all classes, dam foundation	570,000	m^3	1.95	1,111,500		
4	Excavation, rock, for grout cap	1,400	m^3	80.00	112,000		
5	Excavation, common, in borrow areas and transportation to embankment	2,600,000	m^3	2.75	7,150,000		
6	Earthfill in dam embankment	2,300,000	m^3	0.65	1,495,000		
7	Rockfill in dam embankment (transportation of 6 km and placing)	3,100,000	m^3	0.50	1,550,000		
8	Riprap on upstream slope of embankment	110,000	m^3	11.00	1,210,000		
9	Pressure grouting, all work and material	Lump sum		Lump sum	833,000		
10	Furnishing and constructing 20 cm conc. pipe toe drains with open joints	400	lm	21.00	8,400		
11	Furnishing and constructing 30 cm conc. pipe toe drains with open joints	650	lm	37.00	24,050		
12	Access road, 2 lane gravel, Amarti Dam to Neshe Dam. Flat terrain.	5	km	27,000.00	135,000		
13	Bridge across Amarti River below dam	3,300	m^2	270.00	891,000		
	Equalizing Channel--Open cut; length, 935 meters; b = 60 meters; max. cut, 61 meters						
14	Excavation, common	1,000,000	m^3	0.82	820,000		
15	Excavation, rock	1,500,000	m^3	6.50	9,750,000		
	Outlet Works--Capacity, 20 m^3/sec; 1.73 m dia. steel pipe in 3.05 m. horse shoe conduit.						
16	Excavation, all classes, open cut	55,000	m^3	3.25	178,750		
17	Concrete--intake structure	45	m^3	180.00	8,100		
18	Concrete--conduit	1,810	m^3	160.00	289,600		
19	Concrete--gate chamber	165	m^3	210.00	34,650		
20	Concrete--substructure control house	285	m^3	150.00	42,750		
21	Concrete--superstructure control house	30	m^3	210.00	6,300		
22	Concrete--stilling basin	340	m^3	150.00	51,000		
23	Reinforcement	270,000	kg	1.00	270,000		
24	Trashracks	Lump sum		Lump sum	10,000		
25	Slide gates	Lump sum		Lump sum	240,000		
26	Steel outlet pipe	Lump sum		Lump sum	67,500		
27	Minor mechanical & electrical items	Lump sum		Lump sum	17,500		
28	Minor items, misc. metalwork, etc.	Lump sum		Lump sum	70,200		
	Subtotal				26,577,800		
	Contingencies (25±%)				6,644,400		
	Field Cost--Neshe Dam				33,222,200		
	Engineering and General Expense (20±%)				6,644,800		
	Total est. const. cost--Neshe Dam				39,867,000		

TABLE V-3

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN-ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project AMARTI-NESHE--Multiple-purpose

Date of Estimate November 1963

Prices as of January 1961

Currency in terms of Ethiopian Dollars

(U.S. $1.00 = Eth. $2.50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	IRRIGATION CANALS -- Unlined (Continued)						
	North Main Canal -- Length, 29.4 kms; capacity, 3.5 to 2.1 ^{3}/sec.					(782,900)	(979,000)
1	Canal excavation, common	158,300	m^3	0.82	129,806		
2	Canal excavation, rock	17,600	m^3	8.00	140,800		
3	Compacting embankment	43,500	m^3	0.98	42,630		
4	Structures	Lump sum		L.S.	263,000		
5	Gates, hoists, valves and misc. metalwork	Lump sum		L.S.	6,265		
6	Concrete pipe	Lump sum		L.S.	12,500		
7	Other miscellaneous work	Lump sum		L.S.	31,300		
	Subtotal				626,301		
	Contingencies (25±%)				156,599		
	Field Cost -- North Main Canal				782,900		
	Engineering and General Expense (25±%)				196,100		
	Total est. const. cost-- North Main Canal				979,000		
	IRRIGATION DISTRIBUTION SYSTEM -- Unlined, open lateral system for 8,490 net hectares on both sides of the Neshe River.					3,502,100	4,377,000
1	Distribution system served by the South Main Canal. Net hectares.	6,360	ha	330.00	2,098,800	(2,623,500)	(3,279,000)
	Contingencies (25±%)				524,700		
	Field Cost -- Served by S. Main				2,623,500		
	Engineering and General Expense (25±%)				655,500		
	Total est. const. cost -- Served by S. Main				3,279,000		
2	Distribution system served by the North Main Canal. Net hectares.	2,130	ha	330.00	702,900	(878,600)	(1,098,000)
	Contingencies (25±%)				175,700		
	Field Cost -- Served by N. Main				878,600		
	Engineering and General Expense (25±%)				219,400		
	Total est. const. cost-- Served by N. Main				1,098,000		
	DRAINAGE SYSTEM -- Open lateral drains for 8,490 net hectares of irrigated land.					1,485,800	1,857,000
1	Drains for lands served by the South Main Canal. Net hectares.	6,360	ha	140.00	890,400	(1,113,000)	(1,391,000)
	Contingencies (25±%)				222,600		
	Field Cost -- Drains, S. Main				1,113,000		
	Engineering and General Expense (25±%)				278,000		
	Total est. const. cost-- Drains for S. Main				1,391,000		
2	Drains for lands served by the North Main Canal. Net hectares.	2,130	ha	140.00	298,200	(372,800)	(466,000)
	Contingencies (25±%)				74,600		
	Field Cost -- Drains, N. Main				372,800		
	Engineering and General Expense (25±%)				93,200		
	Total est. const. cost -- Drains for N. Main				466,000		

TABLE V-3

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN—ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project: AMARTI-NESHE--Multiple-purpose

Date of Estimate: November 1963

Prices as of: January 1961

Currency in terms of Ethiopian Dollars

(U.S. $ 1.00 = Eth $ 2.50)

ITEM NO.	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	POWERPLANT--Hydro					29,797,300	37,247,000
1	Powerplant structure and improvements, masonry and reinforced concrete.	Lump sum		Lump sum	1,980,000	(1,980,000)	
	Waterways					(20,382,300)	
2	Penstocks; welded steel, 2-1.524 meters I.D., 16 to 48 millimeters thick. Two each, 1467 meters long, piers and anchorages, and 2-1.68 m butterfly valves with controls	Lump sum		Lump sum	20,219,800		
3	Tailrace excavation, common	Lump sum		Lump sum	162,500		
4	Turbines and Generators--Two units, 50,000 kva, 13.2 kv, 0.8 pf, 50 cycle generators, and 56,500 English hp, 375 rpm, 560 meter head, impulse-type horizontal turbines.	Lump sum		Lump sum	5,280,000	(5,280,000)	
5	Accessory electrical equipment--All equipment required for control and protection of generators, and station service power.	Lump sum		Lump sum	1,210,000	(1,210,000)	
6	Miscellaneous equipment--Equipment required for general station use.	Lump sum		Lump sum	770,000	(770,000)	
7	Access road--Two lane, crushed rock, from Irrigation Div. Dam to Powerplant.	3.5	km	40,000.00	140,000	(175,000)	
	Contingencies (25±%)				35,000		
	Engineering and General Expense (25±%) Items 1 through 7						(7,449,700)
	TRANSMISSION LINES, SWITCHYARDS, AND SUB-STATIONS					12,093,000	14,563,000
1	Neshe Switchyard--Located near Neshe Powerplant.					(1,831,000)	
	Single breaker line bay, 161 kv, 1,200 ampere, complete.	Lump sum		Lump sum	300,000		
	Single bay, 161 kv, switch installation only, 1,200 ampere, complete.	Lump sum		Lump sum	100,000		
	Three-phase transformers, 50,000 kva, 13.2-93/161 kv, installation complete, two required.	Lump sum		Lump sum	1,431,000		
	Engineering and General Expense (25±%)						(458,000)
2	Transmission line--Neshe Switchyard to Dongi Substation. 161 kv single-circuit steel tower with one overhead ground wire and three 954 MCM ACSR conductors.					(1,408,000)	
	Rough terrain, much clearing	8	km	50,000.00	400,000		
	Average terrain little clearing	24	km	42,000.00	1,008,000		
	Engineering and General Expense (20±%)						(282,000)
3	Transmission line--161 kv Dongi Substation to Gafarsa Substation No. 2 near Addis Ababa. Stringing second circuit on towers included in Finchaa estimate to complete double-circuit line.					(3,224,000)	
	Furnish and install three 954 MCM ACSR conductors.	248	km	13,000.00	3,224,000		
	Engineering and General Expense (10±%)						(322,000)

TABLE V-3

RECONNAISSANCE ESTIMATE

BLUE NILE RIVER BASIN—ETHIOPIA

ADDIS ABABA, ETHIOPIA

Project: AMARTI-NESHE--Multiple-purpose

Date of Estimate: November 1963

Prices as of: January 1961

Currency in terms of Ethiopian Dollars

(U.S. $ 1.00 = Eth. $ 2.50)

	ITEM	QUANTITY AMOUNT	QUANTITY UNIT	EQUIPMENT MATERIAL AND LABOR UNIT COST	EQUIPMENT MATERIAL AND LABOR COST	FIELD COST	TOTAL CONSTRUCTION COST
	TRANSMISSION LINES, SWITCHYARDS, AND SUB-STATIONS (Continued)						
4	Gafarsa Substation No. 2--Stage 02 (near Addis Ababa), 100,000 kva, 161/132 kv. (See Dwg. 4.0-BN-174)					(4,430,000)	
	Bay Y4	Lump sum		Lump sum	300,000		
	Bay Y2	Lump sum		Lump sum	290,000		
	Bay W4	Lump sum		Lump sum	240,000		
	Bay W5	Lump sum		Lump sum	250,000		
	Reactive control facilities, complete.	Lump sum		Lump sum	1,750,000		
	Autotransformer KY3A and appurtenances	Lump sum		Lump sum	1,600,000		
	Subtotal				4,430,000		
	Engineering and General Expense (25±%)						(1,108,000)
5	Dongi Substation, 161-kv switching between Neshe and Finchaa transmission lines. Two single circuits in, one double circuit 161 kv out.					(1,200,000)	
	Four single breaker line bays, 161 kv complete.	Lump sum		Lump sum	1,200,000		
	Engineering and General Expense (25±%)						(300,000)
	MISCELLANEOUS JOINT-USE FEATURES					4,100,000	5,125,000
1	Access road from Finchaa Project road to Amarti Irrigation Diversion Dam. Rolling terrain.	35	km	40,000.00	1,400,000		
2	Access road from Shanbo-Finchaa River crossing to Amarti Dam. Rolling terrain.	12	km	40,000.00	480,000		
3.	Permanent camps, including offices, shops and housing. Upper and Lower camps.	Lump sum		Lump sum	1,400,000		
	Subtotal				3,280,000		
	Contingencies (25±%)				820,000		
	Field cost--Misc. Joint-Use Features				4,100,000		
	Engineering and General Expense (25±%)				1,025,000		
	Total est. const. cost--joint-use features				5,125,000		

TABLE V-3

TABLE V-4 - ESTIMATED CONSTRUCTION COST SUMMARY
AMARTI-NESHE PROJECT

Feature	In thousands of Ethiopian dollars				
	Total construction cost	Joint-use		Total irrigation features	Total power features
		Power	Irrigation		
Nesha Dam and Reservoir	39,867	30,140	9,727	9,727	30,140
Amarti Dam and Reservoir	12,267	9,274	2,993	2,993	9,274
Power Canal	2,213	---	---	---	2,213
Power Tunnel	2,251	---	---	---	2,251
Powerplant and Penstocks	37,247	---	---	---	37,247
Transmission Plant	14,563	---	---	---	14,563
Irrigation Diversion Dam	280	---	---	280	---
South Main Canal	1,994	---	---	1,994	---
North Main Canal	979	---	---	979	---
Distribution System	4,377	---	---	4,377	---
Drains	1,857	---	---	1,857	---
Access Roads	2,938	2,221	717	717	2,221
Permanent Camp Facilities	2,187	1,653	534	534	1,653
Subtotal	123,020	43,288	13,971	23,458	99,562
Development Cost 1/	3,014	---	---	3,014	---
Total Construction Cost	126,034	43,288	13,971	23,472	99,562

1/See SECTION VIII for details.

SECTION VI - IRRIGATION DEVELOPMENT

FINCHAA PROJECT

Introduction

The lands at the lower end of the Finchaa valley west of the river were initially classified and evaluated on the assumption that they would be served in the same manner as the remainder of the project from a gravity diversion at the upper end of the Finchaa valley. Subsequent studies show that this area can be more economically served from water stored in a reservoir on the Neshe River. This reservoir would be located on the plateau area west of the Finchaa valley. Because an important tributary to the Neshe River, known as the Amarti River, flows from the plateau and empties into the Neshe below the escarpment, this portion of the original Finchaa River Project is considered a part of the Amarti-Neshe Project. Lands in the Amarti-Neshe valleys, as well as those near the Finchaa River, are included in the Amarti-Neshe Project. Due to the close integration of the Finchaa Project and the Amarti-Neshe Project plans and the possibilities of irrigation service from either of two sources on some lands, the land resource data are consolidated into a single presentation. That portion of the Amarti-Neshe Project situated in the Amarti-Neshe valleys was only classified by aerial observation, and the data are projected primarily from the information available from the Finchaa valley; therefore, the accuracy of classification of this area is lower than that of the Finchaa valley. The Finchaa Project area is about twice as large as that of the Amarti-Neshe. Separable data on the estimated irrigable acreages for both projects will be presented.

General Description

Location and Extent

The Finchaa Basin occupies an upland valley position in the eastern portion of Wellegga Province near the center of the Blue Nile Basin. The Finchaa River rises in the mountains which lie to the north of the Addis Ababa-Lekkemt highway between the Guder

River drainage and the village of Baco. The tributaries flow generally northward into the Chomen Swamp, a vast flat area on the plateau lying between the mountains and the precipitous escarpment forming the northern limit of the plateau. The river leaves the swamp and plunges abruptly over the escarpment, which is several hundred meters high. It then flows through the Finchaa valley and tumbles downward through some rough terrain to its confluence with the Blue Nile River.

The Finchaa valley lies in a box-like canyon about 12 kilometers wide and 37 kilometers long. It is bounded on the south, east, and west sides by high, nearly vertical escarpments at the edge of the relatively flat upland plateau approximately 750 meters (2500 feet) above the valley floor. Low hills near the lower end of the valley form the western boundary, which separates the Finchaa and the Amarti-Neshe drainageways.

The Finchaa and Amarti-Neshe River valleys are contiguous with each other and are located within the general boundaries of latitude 9° 35 minutes to 9° 55 minutes North and longitude 37° 15 minutes to 37° 28 minutes East.

Physiography

The Finchaa valley slopes to the northward at an average rate of slightly less than one percent, and the land areas on either side of the river slope to the center at an average rate of about two percent. The project lands are dissected by many tributary channels varying in depth from shallow swales to vertical cuts of 20 meters or more. The stage of erosion indicates a young or very early maturity type of topographic surface.

Although no data are available on the Amarti-Neshe valleys, it is probable that these valleys are ancient alluvial depositions overlying metamorphic rock. These valleys have a dendritic type erosional pattern similar to the Finchaa valley.

Transportation and Habitation

Both the Finchaa and the Amarti-Neshe River valleys are uninhabited and uncultivated. There are a few foot and game trails, but no roads exist. The nearest all-weather market road is at Gedo, approximately 60 kilometers from the upper end of the Finchaa valley. The escarpment which virtually surrounds the Finchaa valley is about 750 meters high and will create a problem in any attempt to construct a road from the plateau to the valley. The plateau areas adjoining the Finchaa and the Amarti-Neshe River valleys are inhabited, and much of this area is cultivated.

Present and Potential Land Use

The vegetative cover over the project areas consists of a fairly dense growth of tropical savannah woodland, typified by acacia, fig, and other varieties of deciduous trees and shrubs, interspersed with a very dense growth of tall grass. With the exception of trees growing in the stream bottoms, which often reach a height of about 30 meters (100 feet), the usual trees on arable land attain a maximum height of about 9 meters (30 feet) and a maximum diameter of about 1/2 meter (20 inches). An occasional area of grass occurs, occupying a rather flat or lowland position, but these areas comprise a small percentage of the total area. Seasonal burning of the grass is practiced.

A large variety of crops could be grown because of the long growing season. However, the cool nights limit the production of some crops. The most likely crops under irrigation would include coffee, corn, sorghum, field beans, tobacco, peppers, castor beans, flax, and other oilseeds. Some subtropical fruits could be grown if desired.

Tsetse flies and mosquitos are common throughout these valleys, and it is probable that malaria would be a problem requiring attention for the successful operation of an irrigation project.

Project Lands

Topography and Land Development

As previously indicated, the Finchaa and the Amarti-Neshe River valleys are dissected by their respective river channels and each valley has numerous, well incised tributary channels. The tributaries are usually entrenched into the valley soils from 2 to 15 meters or more.

Irrigation development will be faced with several problems associated with the present land use and topography. Clearing the land of brush and trees will be a prerequisite to any type of irrigation development. Based on prices for clearing in the United States and Africa, the estimated average clearing costs will be about Eth$230 per hectare. It seems likely that much of the wood could be used for household purposes, such as fuel, charcoal, and brush fences.

The slope of the valley is greater than would be desired for control of erosion, but it lends itself readily to water spreading with minimal expense for land leveling. Only a small portion of the

land has slopes less than 1 percent. It is estimated that leveling costs for minimal land development would be about Eth$125 per hectare.

The arable lands occur on the ridges and side slopes of a valley plane dissected by a well entrenched dendritic type immature drainage pattern. The tops of the ridges generally vary in width from 300 to 1,000 meters, and are usually from 1 to 2 percent in slope. On both sides of these ridges the land increases in slope to the bottom of the drainages. Side drainage from each ridge creates problems for water distribution. A substantial portion of the arable land area has slopes of 2 to 8 percent and there is also a considerable acreage of land with slopes 8 to 12 percent. Because of the subreconnaissance nature of the classification and the scale of the base maps, a considerable acreage of nonarable topography in and immediately adjacent to the drainageway was included in the arable delineations. More refined classifications will exclude most drainageway as nonarable. Further study is needed to determine the maximum slopes permissible for irrigation under the local conditions. Erosion hazards may require that lands with steep slopes be declared not suitable for irrigation. Slopes up to 12 percent were included as arable in this classification.

Although the slope of the land and the erosive nature of the soil are best suited to irrigation by sprinkler procedures and there is sufficient natural slope to develop gravity pressure for this type of system, engineering and other considerations indicate that a simple, gravity type, irrigation system, utilizing contour ditches, will be most practical at this stage. The gravity method is a good first step to more refined irrigation system. Basin type irrigation with adequate drop structures to control surface wastes from rain and irrigation may be considered as an ultimate goal.

Disposal of rain and irrigation wastes could be an important problem in this project. Although there are a great number of natural wasteways, the erodibility of the soils and the steep slope of the lands are such that without proper wasteways the erosion could develop numerous, deep, vertical walled drainageways that would wash away the soil resources and increase the costs for operating and maintaining the project.

Although most of the tributary drainages are well incised, it is possible that drainage waters emanating from the adjacent plateau areas could damage canals or other irrigation facilities during periods of unusually high runoff unless care is taken to assure that irrigation facilities are designed to accommodate such floods.

Drainage

Natural surface drainage facilities are generally excellent to excessive. Excess surface waters will quickly find a natural drainage channel for return to the river. However, as indicated in the foregoing discussion of the topography, such surface wastes could cause serious erosion problems unless suitable erosion control drop structures or well grassed drainageways are provided. This erosion problem could result in a substantial land development cost in areas where erosion hazards are worst. In some of the larger tracts, the surface wastes can perhaps be kept on the ridges for reuse to minimize this problem.

Because of the slope and generally permeable nature of the soil in association with the numerous, deeply entrenched, natural drains, adequate control of a water table under irrigation appears feasible. However, the underlying basalt in the project area is believed to be less fractured and less permeable than that which occurs in the high plateau areas, so very little percolation through the basalt can be anticipated. Prior to construction, detailed drainage studies should be made. This should include a study of the existing water table behavior, a study to determine if any dikes occur that would impound ground water, an evaluation of present vegetation for evidence of wet areas, and suitable pump-in tests to determine the in-place permeability. Studies on the need for and location of erosion control structures in present drainageways are also needed.

Soils

The red latosols occupy the bulk of the project areas. These soils are typical of those developed under well-drained conditions in tropical or subtropical areas. They have a deep and generally freely drained profile. The clay fraction usually has a high percent of kaolinite and lesser amounts of illite clay minerals. They have a low cation exchange capacity, low base saturation, and considerable acidity. A common characteristic of these soils is a high phosphate fixation.

Although the latosols are low in plant nutrients, they have physical properties well suited to irrigation. They are normally well aerated and they can be cultivated over a wide range of moisture conditions. The soil textures are usually clay. However, the nonexpanding type minerals in these soils result in a physical condition about like a loam soil with expanding type clay minerals. Soil crusting is not common.

Mulching of latosols is usually advocated for maximum production. Such mulches as banana leaves or elephant grass can be used to cover the soil where the growing crops are not grown to improve productivity. This treatment tends to reduce the soil temperatures, reduce evaporation, and maintain a favorable soil structure. This treatment should be a goal for future management of the project soils under irrigation.

Grumusols occupy a small percentage of the Finchaa and Amarti-Neshe valleys. These soils have quite different properties than the latosols. The obvious difference is that grumusols are black as compared to the red color of the latosols. For this reason, these two soils are often called "black" or "red" when discussing tropical or subtropical soils.

The grumusols are composed of swelling-type clay minerals such as beidellite or montmorillonite. Therefore, these soils crack badly at the surface when drying. Grumusols usually develop in a warm humid climate where there is a large supply of calcium carbonate or where subsurface drainage conditions are restricted. They are usually neutral to alkaline in reaction and are relatively low in organic matter, even though their color is nearly black. When moistened, the clay swells and the soil becomes sticky, plastic, and almost impervious. Low productivity is usually due to these adverse physical features rather than to the inherent fertility or lack of it. Grumusol soils are rich in lime, but are usually low in phosphorous and nitrogen. They are usually more susceptible to erosion than the latosols, but both soils erode rather easily.

It seems probable that the soil materials in these project areas were deposited in the valleys from the high plateau areas at an early stage of geology following the volcanic eruption that resulted in the basalt flow. Although the soils are mostly latosols and generally fine textured, there are considerable variations within the soils locally.

Near the escarpments on either side of the Finchaa valley, the soils are strongly influenced by the high, massive sandstone formations. Soils tend to be coarser near these escarpments and in the upper half of the project than they are near the river or in the lower half. Although a few sandy loam or coarser soils exist near the escarpment, the predominant surface textures are sandy clay loam, clay loam, and light clay. Below 45 cm the subsoil textures are clays in most instances. The soils are all quite erosive and great care will be needed to prevent deep headcuts and ravines from developing.

A typical latosol profile consists of 15 cm of dark reddish-brown, nonsaline, noncalcareous sandy clay loam, with a pH of about 5.2. From 15-45 cm is dark red clay which has a pH of near 6.0. Red friable clay having a mildly acid reaction occurs below 45 cm to bedrock. The profile has a feeling of much lighter texture than the clay textural description, because the clays are nonsticky. These soils are friable, very permeable, and well suited for irrigation.

Sandstone cobbles occur on the surface of some soils, particularly in the upper part of the Finchaa valley and also near the escarpments. Basalt cobbles also occasionally occur in some soils, but are not believed to be any hindrance to irrigation development.

In the lower half of the Finchaa valley and in the Amarti-Neshe Project, the soils are mixtures of latosols and grumusols with a large predominance of latosols. The soil textures in these areas tend to be finer throughout the profile than in the upper part of the Finchaa valley, and the soils are all less friable and permeable than the soils in the upper basin. The grumusol soils crack when dry, and are quite sticky when wet. Permeability is low in such soils and greater skill will be needed in farming than in the latosol soils. Trees do not grow well in the grumusol soils, and these soils usually have only a grass cover under present conditions.

Land Classification

The subreconnaissance land classification of the Finchaa Basin was accomplished during the rainy season by use of helicopter, because of the inaccessibility of the valley by other forms of transportation. The mapping was done on 1:50,000 contact aerial photographs. Traverses were spaced at about 1 kilometer intervals and landings were made wherever possible. Owing to the dense forest cover, the only treeless spaces available for landings were the small areas of black soil or an occasional gravel bar on the Finchaa River. From these landings it was necessary to travel through the dense underbrush and tall grass on foot to appraise the various soil conditions. Under these conditions, most of the land appraisals necessarily had to be done from the helicopter without the benefit of soil borings and careful morphological studies. It is recognized that there will likely be a considerable reduction in acreage suitable for irrigation when detailed studies are made. Although it is believed that most soil conditions are reasonably favorable for irrigation, topographical conditions are less favorable. Detailed studies will eliminate some

rough lands--particularly drainageways--which are presently not separated as nonarable. Because of the rough nature of the classification and the inability to study the variations of the land class determinating factors, only two arable land classes were delineated. These were Classes 2 and 3. Detailed studies may show that considerable Class 1 land exists. The standards used in classifying these lands are shown in Table VI-1.

Class 2 lands within the project areas consist of deep, friable, permeable, well drained, latosol soils. Slopes are usually in the range of 1-3 percent, but a few areas of slopes to 7 percent are included. Nearly all of these lands are covered with grass, brush, and trees which must be removed prior to irrigation. A small amount of rock removal will also be needed on some lands. After they are developed for irrigation, Class 2 lands will be capable of growing any climatically adapted crop if properly managed. These soils are inherently low in fertilility and will require commercial or animal fertilizer if full production is to be achieved. The Class 2 lands represent 67 percent of the arable land, and are placed in this class mainly because of topographic deficiencies.

Class 3 lands generally are the lands which occupy the side slopes of the numerous drainageways, but also include some rougher, rolling type topography, some stony lands, and the areas of grumusol soils which were observed. The greater portion of Class 3 lands has a slope ranging from 5 to 12 percent. These lands generally have more and larger trees than the Class 2 lands, will be more difficult to farm, and will be less productive. Although most of the soils are latosols and are well adapted to diversified crop production, the steeper slopes and greater danger of erosion are such that these lands require better management than the Class 2 lands. More grass and close growing crops and fewer cultivated crops should be used on these lands than on the Class 2 lands. Class 3 lands occur on 33 percent of the arable area. It can be anticipated that a portion of these lands will be classified as nonarable in a detailed study.

Class 6 lands include some excessively stony lands, the steeper and rougher drainageways, and other complex, rough topography. These lands total approximately 10 percent of the gross area classified.

The results of the classification are set forth in Table VI-2, and the location of the lands is shown on Drawings No. 7.1-Fi-3 and 2.0-Fi-13.

TABLE VI-1

SUBRECONNAISSANCE LAND CLASSIFICATION STANDARDS--BLUE NILE BASIN

Land characteristics	Class 1--Arable	Class 2--Arable	Class 3--Arable	Class 6--Nonarable
Soils				
Texture	Sandy loam to friable, very permeable non-plastic clay	Loamy sand to friable, permeable nonplastic clay	Loamy sand to plastic, slowly permeable clay	Sand and gravel
Minimum depth (cm)				
to bedrock	150	105	75	<75
to volcanic tuff	120	90	60	<60
to clean sand, gravel, or cobble	90	60	45	< 45
Topography				
Permissible slope				
Uniform	0 - 3.0%	3.1 - 7.0%	7.1 - 12.0%	>12.0%
Nonuniform	-	0 - 3.0%	3.1 - 7.0%	> 7.0%
Surface leveling	Smoothing only	Moderate grading	Heavy grading	Very heavy grading
Clearing of rocks or vegetation	Low cost	Moderate cost	High cost	Very high cost
Drainage				
Anticipated cost	Low	Moderate	Moderate	High

132

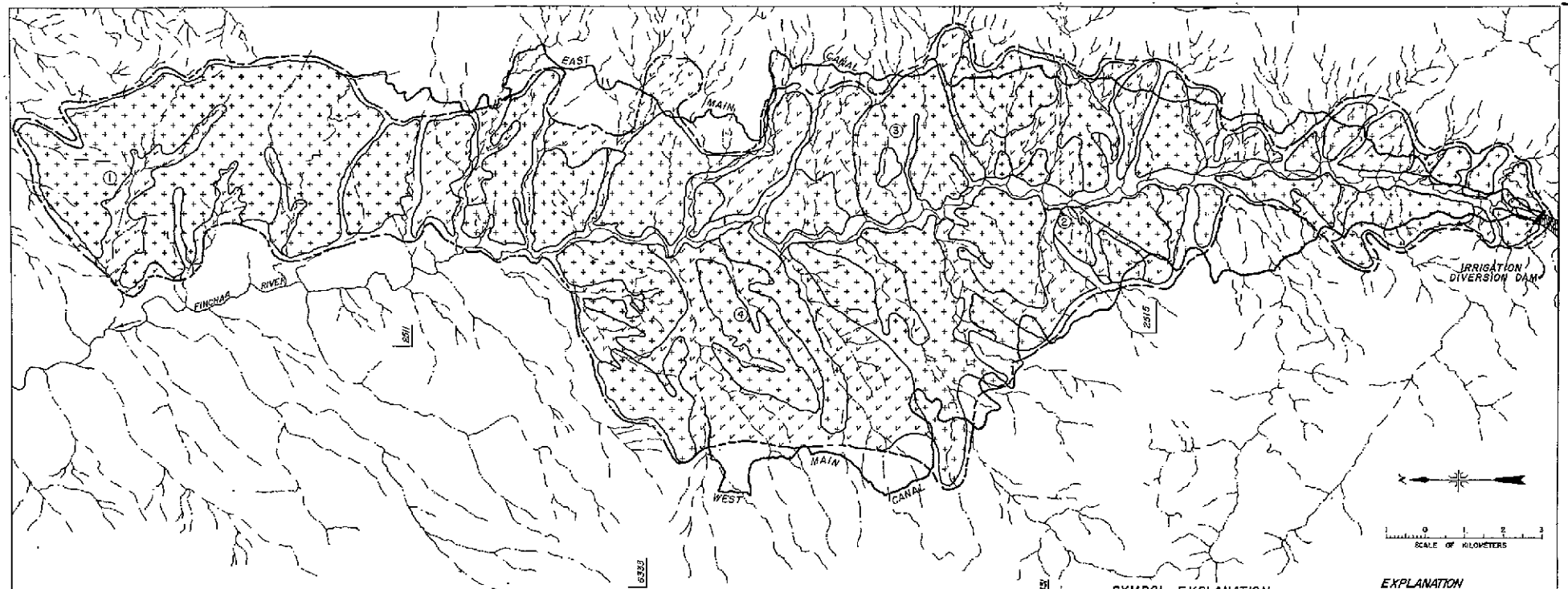
TABLE VI-2

ARABLE AND IRRIGABLE AREAS--FINCHAA AND AMARTI-NESHE PROJECTS

Project	Land type	Land class areas (hectares)			
		1	2	3	Totals
Finchaa	Total arable	--	14, 954	7, 566	22, 520
	Arable below canal	--	13, 460	6, 644	20, 104
	Irrigable	--	10, 000	5, 000	15, 000a/
Amarti-Neshe	Total arable	--	7, 967	3, 696	11, 663
	Arable below anal	--	7, 800	3, 520	11, 320
	Irrigable	--	5, 771	2, 719	8, 490a/

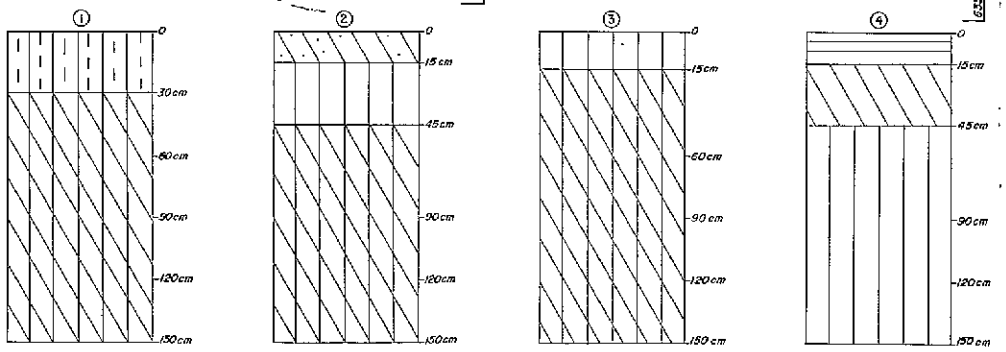
a/Based on estimate that 75 percent of arable land below canal will be irrigable.

133



TABULATION OF LAND CLASSES

	CLASS 2	CLASS 3	TOTAL
TOTAL ARABLE HECTARES	14,954	7,566	22,520
ARABLE HECTARES BELOW CANAL	13,460	6,644	20,104
IRRIGABLE HECTARES	10,000	5,000	15,000



HOLE Nº 1

(PHOTO Nº 2511 HOLE Nº 1)

Smooth gently sloping area burned – shortgrass plus acacia, elevation 4200 ft. Surface cracks – very dark gray to very dark brown s p. clay, area is an assoc of red plus dark clays.

HOLE Nº 2

(PHOTO Nº 2515 HOLE Nº 1)

Gently sloping dissected by small drains – some sandstone cobble on surface – acacia, other trees and tall grass 0–15 cm dark red brown s c l; 15–45 cm dark red brown s c over very dark gray s p. compact s c elevation 4800 ft.

HOLE Nº 3

(PHOTO Nº 2515 HOLE Nº 2)

4% smooth slope – some dissection by small drains – acacia, other trees and tall grass (hole in burned area) Elevation 4800 ft, 0–20 cm very dark brown p. clay with grass roots over very dark brown compact s p c few sandstone cobble on surface.

HOLE Nº 4

(PHOTO Nº 633N HOLE Nº 1)

4% smooth slope acacia, other trees and tall grass – some small Quartzite (?) on surface many termite ties, 0–15 cm dark red brown loam to c l 15–45 cm dark red brown c l to v p c, 45 cm plus dark red friable v.p.c.

SYMBOL EXPLANATION

SOIL PROFILE

- Permeable clay
- Slowly and very slowly permeable
- Very permeable clay
- Permeable clay with some sandstone cobble on surface.
- Permeable, Alluvial, rolling with 3 to 4% slope
- Clay loam textured soil, friable and permeable clay

EXPLANATION

- CLASS 2 ARABLE
- CLASS 3 ARABLE
- CLASS 6
- BOUNDARY OF LAND CLASS
- EXTENT OF LAND CLASSIFICATION

Land classification by R G Throlfhill
Assisted by Zoudie Telahun

Base map compiled from 1 to 50,000 uncontrolled aerial photographs Elevations from altimeter

THIS DWG SUPERSEDES DWG No 7 I – Fi – 2

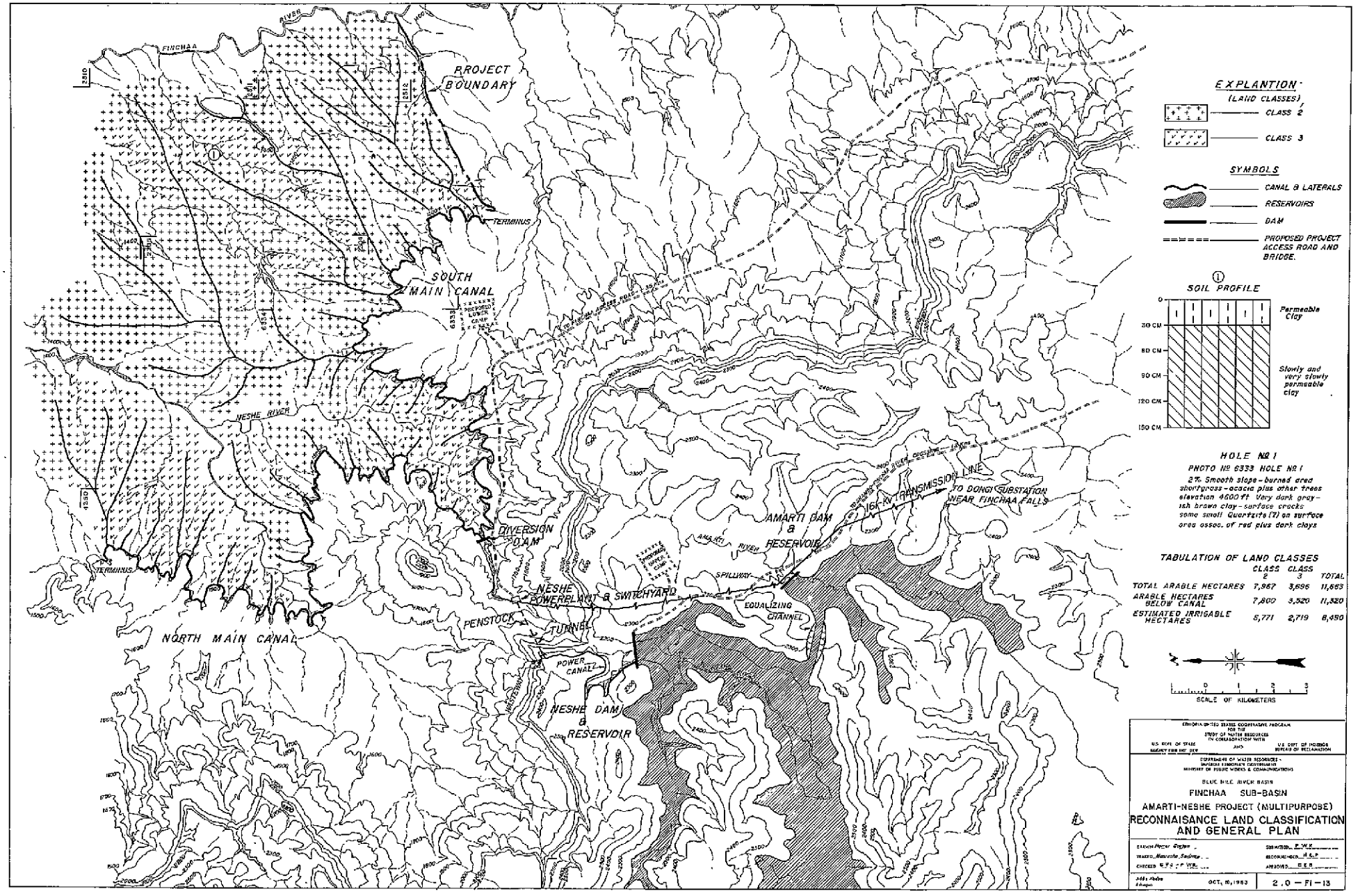
ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH
U.S. DEPT. OF STATE AGENCY FOR INT DEV AND U.S. DEPT. OF INTERIOR BUREAU OF RECLAMATION

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN
FINCHAA SUB-BASIN
RECONNAISSANCE LAND CLASSIFICATION
AND SOIL PROFILES
FINCHAA RIVER AREA

DRAWN R.G. Throlfhill — SUBMITTED R.D.C. – P.W.K.
TRACED Mesgenan Gaitane — RECOMMENDED R. L. P.
CHECKED R.G.T. – P.W.K. — APPROVED C.F.R.

Addis Ababa Ethiopia — JUNE 27, 1962 (I C) — 7.I – Fi – 3


FINCHAA RIVER
PROJECT BOUNDARY
TERMINUS
SOUTH MAIN CANAL
PROPOSED LOWER CAMP
NESHE RIVER
DIVERSION DAM
TERMINUS
NESHE POWERPLANT & SWITCHYARD
PENSTOCK
TUNNEL
POWER CANAL
NORTH MAIN CANAL
NESHE DAM & RESERVOIR
AMARTI DAM & RESERVOIR
SPILLWAY
EQUALIZING CHANNEL
TO DONGI SUBSTATION NEAR FINCHAA FALLS
EXPLANTION
(LAND CLASSES)
CLASS 2
CLASS 3
SYMBOLS
CANAL & LATERALS
RESERVOIRS
DAM
PROPOSED PROJECT ACCESS ROAD AND BRIDGE.
SOIL PROFILE
Permeable Clay
Slowly and very slowly permeable clay
30 CM
60 CM
90 CM
120 CM
150 CM
HOLE NO 1
PHOTO NO 6333 HOLE NO 1
2% Smooth slope - burned area shortgrass - acacia plus other trees elevation 4600 ft Very dark grayish brown clay - surface cracks some small Quartzite (?) on surface area assoc. of red plus dark clays
TABULATION OF LAND CLASSES
CLASS 2 CLASS 3 TOTAL
TOTAL ARABLE HECTARES 7,967 3,696 11,663
ARABLE HECTARES BELOW CANAL 7,800 3,520 11,320
ESTIMATED IRRIGABLE HECTARES 5,771 2,719 8,490
SCALE OF KILOMETERS
ETHIOPIAN UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COOPERATION WITH
U.S. DEPT OF STATE AGENCY FOR INT DEV
U.S. DEPT OF INTERIOR BUREAU OF RECLAMATION
DEPARTMENT OF WATER RESOURCES - IMPERIAL ETHIOPIAN GOVERNMENT MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN
FINCHAA SUB-BASIN
AMARTI-NESHE PROJECT (MULTIPURPOSE)
RECONNAISANCE LAND CLASSIFICATION AND GENERAL PLAN
DRAWN Peter Geyer
TRACED Mesfin Sahlu
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
OCT. 10, 1963
2.0 - FI - 13

Agricultural Economics

Agricultural Conditions before Project Development

At present the Finchaa valley, including the sites of the proposed Finchaa and Amarti-Neshe Projects, is uninhabited, uncultivated, and ungrazed. Therefore agricultural production in the area can be said to be nil. All returns from future project development are considered to be increases to the economy, because no pre-project income exists.

Agricultural Conditions after Project Development

Anticipated Cropping Pattern during Irrigation Season. The Finchaa valley, with its low elevation and mild climate, is considered suitable for growing a wide variety of crops. Frost is not a danger, and many subtropical and temperate crops should do well there. However, the area is thought to lie too low, and to be too warm, for the optimum growth of some of the staples of the Ethiopian diet. These include barley, chick peas, lentils, noog, and teff.

The crops that are anticipated reflect both the dietary patterns of the Ethiopian population, and the concept of commercial production for the market. Some of the traditional staples--corn, sorghum, field beans, flax seed and mustard, coffee and peppers--are included, both for use by the project population and for shipment to the central market. And such crops as tobacco, castor beans, and sunflower are projected for both central marketing and export.

One new crop, buckwheat (Fagopyrum esculentum), appears in the projection on a small scale. It is a cereal-like grain which produces a head that can be hulled and ground for flour. Bread made from this flour does not rise, but instead forms a type of pancake or a flat bread similar to the teff or sorghum "injerra" much favored by Ethiopians.

In a test held at the agricultural high school at Jima, flat bread prepared from buckwheat was found palatable by Ethiopians who ate it. Since no teff is projected for the Finchaa area, buckwheat may be a partial substitute. The crop appears adaptable for Finchaa conditions and should yield well.

Corn (maize) and sorghum are two traditional grains grown in Ethiopia, and in many parts of the world. In Ethiopia, corn (Zea mays) is roasted or cooked in stew, or "wat", but generally not ground for flour. The varieties grown on the project should be

selected for suitability for grinding, to introduce this use on a larger scale. Sorghum (Sorghum vulgare) is an indigenous grain used for "injerra," for local beer or "tulla", and roasted. It is a staple of the Ethiopian diet, eaten frequently in many areas. Haricot beans, also called field or navy beans (Phaseolus vulgaris), which resemble small lima beans, are eaten in "wat"; as fresh vegetables; are ground and cooked as a type of porridge; or are roasted. Small quantities are exported for cattle and poultry feed. Peppers (Capsicum annuum and C. frutescens) are a hot species used both as vegetables and as spice. The mature pods are ground and mixed with a combination of other spices and used to flavor the "wat"; cooked whole or in sections in the "wat"; or consumed fresh as a green vegetable. They are eaten daily by the bulk of the population. Mustard (Brassica nigra) and flaxseed (Linum usitatissimum) are two edible oilseeds that are projected for the irrigation season. Both are thought to be indigenous to Ethiopia. The seeds are crushed on the dish in which "injerra" is cooked; added to "injerra" in the dough stage; added to "wat"; used as a salad oil; and manufactured into soap. Flaxseed is also eaten with spices and taken with water for therapeutic purposes. Small amounts of both oils are exported. Coffee (Coffea arabica), supposedly indigenous, is the leading export crop of Ethiopia, and has many domestic uses. The beans are ground to produce the beverage or eaten as cakes; and the skin of the berries is used as a vegetable.

Ethiopian coffee intended for export is subject to quality control by the Ethiopian Coffee Board. Finchaa coffee that is grown, picked, and handled under controlled conditions should be higher in quality than the coffee grown and harvested under the usual "wild", or coffee forest conditions, and should find a place in both the domestic and the export markets.

Crops suggested entirely for commercial usage, with no consumption on the project before processing, include tobacco, castor beans, and sunflower. Tobacco (Nicotiana tabacam), variety Oriental or Turkish tobacco, has been grown in Ethiopia for several centuries. It is produced on a small scale at the present time, but the demand for cigarettes and other tobacco products is expanding. Tobacco products are manufactured by the Imperial Tobacco Monopoly, which presumably would be the outlet for Finchaa leaf. The Oriental variety is better adapted to Blue Nile elevations than the Virginia variety, also grown in Ethiopia. It has smaller leaves, is highly aromatic, and burns quite easily.

The castor bean (Ricinus communis), a plant indigenous to Ethiopia, yields a nonedible, poisonous oil that is used to lubricate jet engines and has usage in the textile, leather, and cosmetic industries. The Finchaa crop is intended for export, but if specialized industry develops in Ethiopia some portion of the crop may eventually be used at home.

Sunflower (Helianthus annus) yields an edible oil that is little known in Ethiopia at the present time, but has many uses overseas. The oil is used in salads, for cooking, as a butter substitute in its solid form, for soap, and as an industrial lubricant. The oilmeal is a valuable cattle feed and a nitrogenous fertilizer, and the whole seed may be consumed by human beings or fed to poultry.

Data on the yield of crops adapted to irrigated conditions in Ethiopia are not readily available. Measures of yield and units of land are seldom known or reducible to a common denominator. Irrigation, as practiced by the average Ethiopian farmer, is an operation which produces a few staple crops and a very limited number of specialty food crops. Observation and survey data indicate that monetary returns under present irrigation do not greatly exceed nonirrigated returns, because of many limiting factors. These include poor distribution of available irrigation water, dependence upon streams with variable flows, a low level of fertility, a low rate of germination due to poor seed, uneven covering of the seed, an uneven and often low plant population, inefficient cultivation, and other negating factors. Therefore, it is not possible to project future yields on the basis of present subsistence irrigation data.

As a basis for estimating crop yields, data were gathered from a wide variety of sources. Estimates were prepared from existing secondary data, which were sparse in detail, and checked with agronomic advisers and agricultural research technicians. Primary yield figures were gathered wherever possible. Most were obtained at the Azienda Agricola in Wello, at the Wonji sugar estate in Shewa, the experimental station at Bishoftu, and from projected figures for the Metahara plantation on the Awash River.

To adapt these scattered figures to expected Blue Nile conditions under project development, the influence of climate was considered most important. The factors which constitute climate, particularly temperature minima and maxima, and frost probability are considered in this report to be functions of elevation. As elevations increase, the daily minimum and maximum temperatures decrease. Frost may occur at the higher elevations within the range of irrigation response. Observations made in the Blue Nile Basin give support to the theory that the time required for plant maturity increases with elevation, and generally that yields are depressed in direct relation to increased elevation. This relationship, believed to exist between crop yields and elevation, has been arithmetically applied to future project areas.

Blue Nile proposed project areas have been placed into elevation categories. The lowest category covers the range from 600 to 700 meters, the second from 700 to 1500 meters, the third

from 1800 to 2000 meters, and the highest covers areas above 2000 meters. No projects are planned below 600 meters, between 1500 and 1800 meters, or above 2200 meters.

The relationship of yield to elevation is plotted in a direct progression. Each successively higher elevation category shows a yield reduction of 15 percent, each lower category an increase of 15 percent. The Finchaa area lies at 1500 meters, and the second highest group of yield is applied.

In this analysis no distinction is made for yields on different land classes. Many variables are encountered, and more reliable data must be available before a supportable estimate can be made for a distinction of this type. Since the data on irrigated crop yields are so scanty, it does not appear prudent to refine the estimates further. A more detailed study, however, may justify differentiation of yields by land classification.

It is recognized that many of the factors influencing crop yield need testing on experimental fields before more refined predictions are possible. Indigenous crops may respond successfully to irrigation, but imported varieties may respond even better. Alternative crops will be developed largely by test and experimentation. Fertility levels, frequency and amount of irrigation, and level of soil acidity are only a few of the factors related to irrigation and mechanization which need testing and which may appreciably modify preliminary yield expectations. Furthermore, the length of day and the hours of sunshine per day may alter the expected response of imported crops.

The assumption has been made that the irrigation season would commence in October and extend to June. Although this period provides a growing season longer than most crops will require, only one planting of each crop is projected for this study. This is done to avoid overstatement of expected monetary returns. But, during actual operations, particularly some years after operations have commenced, replanting with short-season crops would probably follow harvest of the first crops.

The responsibility for a second crop is left to the project. If the cropping pattern is followed, monetary benefits should equal those projected. But if a second planting is made, fuller utilization of the land should result in higher cash returns than are projected.

Anticipated Cropping Pattern during Nonirrigation Season. A second group of crop projections is necessary to determine the response of crops produced without irrigation on Blue Nile Basin

projects. For cropping purposes there are two seasons in the Blue Nile Basin areas--the irrigated season, which extends roughly from October 15 to June 1; and the rainy or nonirrigated season, which covers the rest of the year. During the irrigation season many mechanical practices can be introduced and the amount of water applied to the land strictly regulated. During the rainy season, however, the precipitation falling on the fields is uncontrollable, daytime temperatures are lower, the sun shines fewer hours per day, and yields are understandably lower than levels expected in the irrigation season.

Physical difficulties are also greater in this season. The concentrated heavy rainfall frequently prohibits the use of tractors and other mechanical equipment while muddy fields increase maintenance costs. Therefore, the combination of poor returns, higher operating costs, and difficulty of access to fields places many operations out of the question in this season.

The best solution may be to utilize the land approximately in the way it is used under pre-project conditions in Ethiopia. This is preferable to keeping it fallow for four and one-half months of each year. The fields should be plowed and disked by tractors before the onset of the heavy rains, and sown in short-season, fast-maturing crops, such as certain grains, pulses, and oil seeds. These should be cultivated by hand, mature, and be harvested before the land is plowed for the major irrigation season operations. In addition to fuller utilization of the land, a certain amount of food would be produced, and farmers would be utilized on a year-round basis.

A possible detrimental effect of rainy season farming is damage to the soil tilth caused by working the soil when it is wet or puddled. However, the reddish latosols, which predominate in the Finchaa valley, are much lighter and less plastic than the dark gray clays which abound in many other project areas, and would present less of a problem in this respect. Any soil damage that does occur should be assessed against the value of the foodstuffs produced during the rainy season.

The list of crops suggested for the Finchaa rainy season is confined to corn, millet, haricot beans, and mustard. These crops are all well known and accepted in the basic diet. Coffee, which is projected for five percent of the area, is a perennial crop that may require some cultivation during the rains, but should not be considered an off-season crop.

All crops projected for the rainy season, except millet, are described earlier. African millet or dagussa (Eleusine coracana) is a grain indigenous to Ethiopia and is used on a small scale for "injerra", cereal cakes, roasting, and "wat". It is included to supplement the production of irrigated cereals.

Nonirrigated crop yields are based largely on known yields recorded in sample surveys conducted in Shewa, Wellegga, and Gojjam Provinces. Figures are adjusted by elevation in the same manner as the irrigated crop yields. However, although the nonirrigated crop yields are much lower than irrigated yields, they are projected higher than those presently realized in Ethiopia, to allow for the effects of management, fertilizer, lime, and superior seed.

In the nonirrigation season, 75 percent of the land is expected to be cultivated, compared to 95 percent in the irrigation season. This will allow for some late harvest of irrigated crops, and for the minority of farmers who would prefer to regard the rainy season as a period of unpaid vacation.

Crop Prices. Prices of the crops that will be produced on the Finchaa Project are based upon Addis Ababa or central market, wholesale prices, reduced to reflect the distance from the project area to the central market. Addis Ababa prices for the various commodities, collected for the 1956-1960 period, are essentially the prices paid to the primary producer, plus the cost of hauling. For project purposes a standard reduction factor of Eth$0.80 per 100 kilograms per 100 kilometers of distance is used. This factor was constructed from hauling rates used in Ethiopia in the recent period.

Although a lower rate is found in some parts of the Empire, hauling to the Finchaa area will probably always be expensive due to natural topographic conditions. Produce must move up a steep incline onto the escarpment before it can reach the main road at Gedo.

Prices applicable to the Finchaa Project are listed in Table VI-3. Since the area lies approximately 300 kilometers from Addis Ababa, central market prices are reduced by Eth$2.40 per 100 kilograms. It is assumed that all of the produce sold off the project will be transported to the central market, although it is possible that some yet-unknown quantity will reach other markets for distribution.

TABLE VI-3. WHOLESALE PRICES IN ADDIS ABABA AND IN THE FINCHAA AREA

Commodity	Addis Ababa Eth$/100 kg.	Finchaa area Eth$/100 kg.
Buckwheat 1/	12.00	9.60
Corn	12.58	10.18
Millet (dagussa)	12.30	9.90
Sorghum	16.10	13.70
Haricot (field) beans	18.92	16.52
Flaxseed	23.54	21.14
Mustard	20.15	17.75
Castor beans	29.02	26.62
Sunflower	28.00	25.60
Coffee	164.24	161.84
Peppers (berberi)	58.33	55.93
Tobacco (Oriental)	117.00	114.60

1/ The price for buckwheat is conjectural; no buckwheat is grown in Ethiopia today. The prices for cereals, beans, oilseeds, and coffee include hulling but not cleaning. Pepper and tobacco prices are those for the dry fruit and the dry leaf, respectively.

Summary Sheets. Tables VI-4 and VI-5 are designed to show the agriculture of the Finchaa Project in terms of crop production and of the gross income to be realized from the sale of crops. Table VI-4 shows the returns on the basis of an average 100 hectares, Table VI-5 on a full project, 15,000-hectare basis.

The first portion of each table is intended to show the pattern of cropping, crop yields, crop prices, and income for the area under present conditions. The area is uninhabited and has no present agriculture, therefore only the price column is used, because crop prices are applicable for future as well as present conditions.

The remainder of the tables shows expected conditions under irrigation development. Hectares of each crop, yield per hectare, total crop production, and monetary returns for crops sold are listed.

The total monetary return for the irrigation and nonirrigation seasons is the gross crop income for the area. Since there is no present agricultural income, total future income is considered to be incremental to development of the project.

Under operating conditions the average size of farm in the project area will be 17 hectares (see SECTION IX, Administration and Operation). The average farmer will be farming sixteen hectares during the irrigation season, and using one hectare for the farmstead, farm roads, and woodlot. During the nonirrigation season fifteen percent of the land is expected to lie fallow, so that at this time the average farmer will be cultivating thirteen hectares.

Consumption of Crops. The production of crops in the Finchaa area after project development, shown in kilograms, may also be expressed in nutritional terms. The content of the average Ethiopian diet is known, and is stated to be low in calories, 1/ and inadequate in vitamin A and ascorbic acid. 2/ Improvement of the diet of project residents will be one of the real benefits of developing the Finchaa area. It is assumed that sufficient food will be available for project residents; beyond that, a surplus will be available for sale in the domestic and export markets of Ethiopia.

An average daily intake of 2,900 calories per person is thought to be sufficient, considering the type of work, the climate, and the height and weight of the population. Approximately 85 percent of this requirement will be met by project foodstuffs; the remainder, which is contributed by false banana, onions, potatoes, cabbage, sugar, minor spices, vegetables and fruit, and meat and livestock products, is not scheduled for immediate inclusion in the cropping pattern (see Livestock and Alternative Crops). Therefore, about 2,460 calories per day would originate on the project and the balance of 440 calories per day from other sources. This would assure a diet that is adequate in quantity, and possibly also better balanced. Yearly project consumption of calories under ultimate conditions would be 2,460 per person multiplied by 65,000 people by 365 days per year, or 58,400,000,000 calories. The remainder produced, some 84,463,000,000 calories, will be available for sale.

1/ "The average dietary intake is approximately 2,500 calories. It can be estimated that there may be an average calorie deficit of up to 400 calories per person daily." General Review of Health and Medical Problems in Ethiopia, Weh-Pin Chang, World Health Organization

2/ Ethiopia Nutrition Survey, A report by the Interdepartmental Committee on Nutrition for National Defense, September 1959, p. 40.

TABLE VI-4 . Summary of Farm Income for Estimating Benefits by Use of the Gross Crop Income Method, Finchaa Project, Ethiopia, on a 100-hectare Basis

CROP PATTERN	CONDITIONS BEFORE PROJECT					FUTURE CONDITIONS, IRRIGATION SEASON							FUTURE CONDITIONS, NONIRRIGATION SEASON						TOTAL INCOME	INCREMENTAL INCOME
	CROP 1/ DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	PRICE RECEIVED PER 100 Kg Eth.$	INCOME Eth.$	CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	SHIPMENT TO CENTRAL MARKET Kg	VALUE OF SHIPMENT TO CENTRAL MARKET Eth.$	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth.$	CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth.$		Eth.$	Eth.$
Buckwheat	-			9.60		5	2,000	10,000	7,500	$ 720	2,500	$ 240	-	-	-	-	$ -		$ 960	$ 960
Corn	-			10.18		15	3,175	47,625	41,825	4,258	5,800	590	30	1,180	35,400	35,400	3,604		8,452	8,452
Millet (dagussa)	-			9.90		-	-	-	-	-	-	-	25	975	24,375	24,375	2,413		2,413	2,413
Sorghum	-			13.70		20	2,980	59,600	36,100	4,946	23,500	3,219	-	-	-	-	-		8,165	8,165
Haricot beans	-			16.52		10	1,780	17,800	17,800	2,941	-	-	10	950	9,500	9,500	1,569		4,510	4,510
Flaxseed	-			21.14		5	1,000	5,000	5,000	1,057	-	-	-	-	-	-	-		1,057	1,057
Mustard	-			17.75		5	1,170	5,850	5,850	1,038	-	-	10	700	7,000	7,000	1,242		2,280	2,280
Castor beans	-			26.62		10	2,000	20,000	20,000	5,324	-	-	-	-	-	-	-		5,324	5,324
Sunflower	-			25.60		10	1,800	18,000	18,000	4,608	-	-	-	-	-	-	-		4,608	4,608
Coffee	-			161.94		5	960	4,800	4,100	6,635	700	1,133	5	-	-	-	-		7,768	7,768
Peppers	-			55.93		5	920	4,600	2,100	1,175	2,500	1,398	-	-	-	-	-		2,573	2,573
Tobacco (Oriental)	-			114.60		5	2,000	10,000	10,000	11,460	-	-	-	-	-	-	-		11,460	11,460
Subtotal, Crops	-					95				44,162		6,580	80				8,828		59,570	59,570
Fallow	-					-				-		-	15				-			
Subtotal, Cultivated area	-					95				44,162		6,580	95				8,828		59,570	59,570
Noncultivated irrigable land	100.0					5				-		-	5				-		-	-
Total area	100.0					100				44,162		6,580	100				8,828		59,570	59,570

1/ This project area is uninhabited at present.

144 144A 144B 144C

TABLE VI-5 . Summary of Farm Income for Estimating Benefits by Use of the Gross Crop Income Method, Finchaa Project, Ethiopia, on a Full Project, 15,000-hectare Basis

CROP PATTERN	CONDITIONS BEFORE PROJECT: CROP DISTRIBUTION 1/ ha	YIELD Kg/ha	PRODUCTION Kg	PRICE RECEIVED PER 100 Kg Eth.$	INCOME Eth.$	FUTURE CONDITIONS, IRRIGATION SEASON: CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	SHIPMENT TO CENTRAL MARKET Kg	VALUE OF SHIPMENT TO CENTRAL MARKET Eth.$	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth.$	FUTURE CONDITIONS, NONIRRIGATION SEASON: CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth.$	TOTAL INCOME Eth.$	INCREMENTAL INCOME Eth.$
Buckwheat	-			$ 9.60		750	2,000	1,500,000	1,125,000	$ 108,000	375,000	$ 36,000	-	-	-	-	-	$ 144,000	$ 144,000
Corn	-			10.18		2,250	3,175	7,143,750	6,272,750	638,565	871,000	88,669	4,500	1,180	5,310,000	5,310,000	540,558	1,267,792	1,267,792
Millet (dagussa)	-			9.90		-	-	-	-	-	-	-	3,750	975	3,656,250	3,656,250	361,969	361,969	361,969
Sorghum	-			13.70		3,000	2,980	8,940,000	5,415,000	741,855	3,525,000	482,925	-	-	-	-	-	1,224,780	1,224,780
Haricot beans	-			16.52		1,500	1,780	2,670,000	2,670,000	441,084	-	-	1,500	950	1,425,000	1,425,000	235,410	676,494	676,494
Flaxseed	-			21.14		750	1,000	750,000	750,000	158,550	-	-	-	-	-	-	-	158,550	158,550
Mustard	-			17.75		750	1,170	877,500	877,500	155,756	-	-	1,500	700	1,050,000	1,050,000	186,375	342,131	342,131
Castor beans	-			26.62		1,500	2,000	3,000,000	3,000,000	798,600	-	-	-	-	-	-	-	798,600	798,600
Sunflower	-			25.60		1,500	1,800	2,700,000	2,700,000	691,200	-	-	-	-	-	-	-	691,200	691,200
Coffee	-			161.84		750	960	720,000	615,000	995,316	105,000	169,932	750	-	-	-	-	1,165,248	1,165,248
Peppers	-			55.93		750	920	690,000	315,000	176,179	375,000	209,937	-	-	-	-	-	386,116	386,116
Tobacco (Oriental)	-			114.60		750	2,000	1,500,000	1,500,000	1,719,000	-	-	-	-	-	-	-	1,719,000	1,719,000
Subtotal, Crops	-					14,250				6,624,105		987,463	12,000				1,324,312	8,935,880	8,935,880
Fallow	-					-				-		-	2,250				-	-	-
Subtotal, Cultivated area	-					14,250				6,624,105		987,463	14,250				1,324,312	8,935,880	8,935,880
Noncultivated irrigable land	15,000					750				-		-	750				-	-	-
Total area	15,000					15,000				6,624,105		987,463	15,000				1,324,312	8,935,880	8,935,880

1/ This project area is uninhabited at present.

Minor amounts of meat and animal products might be produced locally by project residents, and garden plots around the homes should be encouraged. Furthermore, tests conducted on the experimental farm might determine that certain vegetables and fruits are suitable for eventual inclusion in the cropping pattern.

Certain crops proposed for the project, including castor beans, coffee, and tobacco are either nonedible or have a very low caloric value. All production of these crops, although not expressible in nutritional terms, must nevertheless be considered net additions to the agricultural economy.

Table VI-6 shows the production and consumption of calories on the Finchaa Project.

Alternative Crops

In the future, as the industrial economy of the country develops and the cities enlarge, cash crops will be in greater demand. The Finchaa Project should gradually turn to those crops which it is best able to produce, and should gradually eliminate those less adaptable and those grown primarily for subsistence. Other project areas, for example, may eventually produce all of the sorghum or haricot beans now projected for Finchaa, leaving a greater proportion of the cropland available for such high-value crops as peppers, coffee, or tobacco. In the future the project area may assume a stronger cash position, shipping the large bulk of its production to the cash markets, and purchasing most of its food requirements from other areas farther from the central market or less climatically adapted to production of specialty crops.

There are many alternative crops that may replace some of the crops suggested. Some of these, however, are less adapted to the Finchaa area, while others might not be as financially remunerative or less acceptable in the Ethiopian diet. Still others may have export possibilities but are unknown today in Ethiopia. Time and experience may allow some of these crops a place within the cropping pattern.

Grains. Four grains are projected for the Finchaa area; buckwheat, corn, sorghum, and African millet or dagussa. The grains are the largest group of crops projected, and are intended partly for production of food for the project population, and partly as surplus to ship off the project. Grains may diminish in importance as the economy grows and demand for coffee, peppers, castor beans, and tobacco increases.

TABLE VI-6 - PRODUCTION AND DISPOSITION OF CROPS, EXPRESSED IN TERMS OF CALORIES

Irrigation Season

Crop 1/	Calories per kg.	Production, kg.	Production, Calories	Shipment to Central Market, Calories	Local Consumption, Calories
Buckwheat	2,757	2,625,000	7,237,125,000	6,203,250,000	1,033,875,000
Corn	3,500	7,143,750	25,003,125,000	21,954,625,000	3,048,500,000
Sorghum	3,620	8,940,000	32,362,800,000	19,602,300,000	12,760,500,000
Haricot beans	3,430	2,670,000	9,158,100,000	9,158,100,000	-
Flaxseed	4,720	750,000	3,540,000,000	3,540,000,000	-
Mustard	4,600	877,500	4,036,500,000	4,036,500,000	-
Sunflower	5,120	3,705,000	18,969,600,000	18,969,600,000	-
Peppers	3,170	690,000	2,187,300,000	998,550,000	1,188,750,000
Subtotal, irrigation season			102,494,550,000	84,462,925,000	18,031,625,000

Nonirrigation Season

Crop	Calories per kg.	Production, kg.	Production, Calories	Shipment to Central Market, Calories	Local Consumption, Calories
Corn	3,500	5,310,000	18,585,000,000	-	18,585,000,000
Millet	3,300	3,656,250	12,065,625,000	-	12,065,625,000
Haricot beans	3,430	1,425,000	4,887,750,000	-	4,887,750,000
Mustard	4,600	1,050,000	4,830,000,000	-	4,830,000,000
Subtotal, nonirrigation season			40,368,375,000	-	40,368,375,000
Total, irrigation plus nonirrigation season			142,862,925,000	84,462,925,000	58,400,000,000

1/ Excluding castor beans, coffee, and tobacco.

The grains selected are adapted to the Finchaa climate, are well accepted in Ethiopian homes and markets, and form an important part of the diet. Only one new cereal, buckwheat, is included. Alternatives include rice, buckwheat, and baltuk.

Rice (Oryza sativa) can be grown up to 1500 meters on irrigated lands, and will thrive on tight, puddled soils. Rice, however, is unknown in the Ethiopian diet, except for some foreign and Moslem groups. Furthermore, rice grown in Blue Nile areas cannot compete on the present world market with Asian, European, and American rice.

Baltuk or pearl millet (Pennesetum glaucum) is a minor indigenous Ethiopian crop. It will grow in the Finchaa area, but does not appear to enjoy as much favor as other grains. Among lowland populations it is more popular.

Cool weather cereals which will not return their best yields in this area include teff (Eragrostis abyssinrea), barley (Horedeum spp.), oats (Avena sativa), wheat (Triticum spp.), and rye (Secale cereale). Oats and rye would encounter severe marketing difficulties as well.

Pulses. The only pulse included in the cropping pattern is the haricot, navy, or field bean (Phaseolus vulgaris). If this crop should not prove successful in the Finchaa or if the area under pulses is expanded, horse beans, field peas, or mung beans might be considered.

Horse beans (Faba vulgaris) are a well-liked indigenous crop, with a good export market. They do not command as high a price as haricot beans, however.

Field peas (Pisum sativum) are an important indigenous food crop, but may be at the borderline of their tolerance for heat in the Finchaa. If planted immediately in the fall, they may mature a crop without loss caused by warm weather. Their most promising use may be as a nonirrigated crop in the rainy season.

Mung beans (Phaseolus aureus) are more tolerant of heat. This crop is not known in Ethiopia today, although efforts to introduce them have been made. Mung beans can be used directly for food or crushed for oil.

Other indigenous pulses, including chick peas (Cicer arietinum); fenugreek (Trigonella foenum-graecum); and lentils (Lens esculenta) probably would find the Finchaa valley too warm.

148

Oilseeds. The cropping pattern lists flaxseed (Linum usitatissimum), mustard (Brassica nigra), sunflower (Helianthus annus), and castor beans (Ricinis communis). Flaxseed and mustard are basic oilseeds in Ethiopia, widely grown and consumed. Sunflower is not a common source of vegetable oil in the Ethiopian diet, but an oil-bearing plant intended primarily for export, with possibilities for gradual introduction into the local diet. Castor beans, although presumed indigenous to Ethiopia, are not edible and find little use in the country. They are intended entirely for export, and for such specialized industries as may develop in Ethiopia in the future. Among future possibilities rape, sesame, safflower, soybeans, and peanuts are the most promising for the Finchaa area.

Rape or rapeseed (Brassica napus) is produced at scattered locations in the Ethiopian highlands. The crushed seeds yield an edible oil, and the young leaves are consumed as a minor leafy vegetable. Rape may also be used for pasture and for poultry green feed. Since rape prefers a cool climate, the Finchaa valley may be somewhat low and warm for optimum development, but a crop planted in the fall may yield well.

Sesame (Sesamum indicum) is grown in the Blue Nile Basin as a minor oilseed. It is considered a promising crop for warm temperate regions. Sesame oil is used for cooking and soap, sesame oilmeal for poultry and livestock feed, and sesame seeds are sprinkled on breads and pastries. The crop may have strong export possibilities.

Safflower or saffron (Carthamus tinctorius), not to be confused with wars, or bastard saffron (Crocus sativus), is a minor indigenous oilseed grown in the highlands for a cooking oil and soap. On the world market, it is a drying industrial oil for varnishes and soap. Formerly it was best known as a source for dye.

Soybeans (Glycine hispida) are cultivated on a very minor scale in Ethiopia at the present time. The crop is adaptable to Finchaa area climatic conditions. Soybeans may be used for meal, oil, as green beans, and as dry beans. Both the meal and the oil have a great many edible and nonedible uses.

Peanuts or groundnuts (Arachis hypogaea) are botanically a pulse but are regarded as an oil seed because of the wide variety of products made from the oil. The climate of the Finchaa is probably quite suitable for peanut cultivation, but peanuts should be grown only on the loose, well drained soils if the tubers are to set properly.

Noog or nigerseed (Guizota abyssinica) is the most important indigenous Ethiopian oilseed. The Finchaa area probably lies too low for commercial production of this crop, however. Another problem is the tendency to shattering of the seed, since this crop has not been improved for machine harvest.

Sugar crops. Sugar cane (Saccharum officinarium) can probably be grown well in the Finchaa area. It will thrive in a warm climate under irrigation, particularly where several dry months occur during ripening. It will grow on a variety of soils, including heavy clays and loams. Furthermore, sugar is accepted in the Ethiopian diet and the consumption is increasing.

Sugar cane, however, is excluded from the cropping projection of the Finchaa and other Blue Nile project areas. At present the entire commercial production is grown by a Dutch plantation at Wonji, near Addis Ababa. This plantation supplies domestic requirements and manufactures sugar candy to create an even larger market. A monopoly, awarded to this firm, prohibits competitive commercial plantings a certain number of kilometers around Wonji.

Sugar beets (Beta altissima) are not strictly adapted to the Finchaa area, because of particular heat and water requirements. If a sugar crop is desired after the project has become established, the respective merits of cane and beets should be re-examined.

Vegetables. Vegetables are not greatly enjoyed in Ethiopia. Vegetable consumption by most people is quite low, although certain varieties are cooked in "wat", others are eaten raw, and still others are liked by certain urban groups. Only the red pepper, which is as much a spice as a vegetable, is consumed to a large extent.

Other known vegetables include onions, potatoes, cabbage, pumpkins, and squash. A coarse member of the cole group, locally called "gomen", and some mustard, rape, and cress leaves are eaten as salad, and small quantities of wild asparagus and mushrooms are gathered. But over-all vegetable consumption, as measured by groups interested in Ethiopian nutritional patterns, is very low. 1/ A serious factor affecting the choice of vegetables, in addition to adaptability and yield, is, therefore, the degree of acceptance in the marketplace.

1/ The Ethiopia Nutrition Survey mentions that vegetables, exclusive of pulses and peppers, supply only 2.6 percent of the daily caloric intake. The Planning Board claims 3.8 percent, and the Limu Survey only 0.7 percent.

150

Many vegetables are culturally adapted to the Finchaa area because the valley has a mild climate and irrigation water will be supplied. The project management might decide, once the operations are established and a certain amount of financial loss is allowable, to try small plantings on the experimental farm. If this were successful and the crops were marketable, then the farmers might consider their propagation. However, garden plantings by private farmers should be encouraged to supplement the diet.

Initial harvest of "exotic" vegetables (those little known in Ethiopia but well accepted elsewhere) could be sold in the foreign markets in Addis Ababa and elsewhere. Gradually these may become accepted throughout the population, a circumstance that has come about in the case of such crops as lettuce, carrots, cauliflower, and fresh snap beans.

Soil conditions are important when vegetables are grown. Most varieties require a well-drained soil, and will yield poorly on a tight clay. The Finchaa area latosols, with good drainage and low plasticity, are suitable for many types. Future vegetable production might become important here, assuming acceptance by the Ethiopian population.

The growing season for most vegetables is so short that there are actually two seasons per irrigation season. This is very significant in regard to heat tolerances. Fall months are generally the cooler and spring months warmer. Therefore, the short-season cool weather crops could be sown at the start of the irrigation season; the heat-loving short-season crops in January and February.

Cool season possibilities:

Root crops: Beet (Beta vulgaris), carrot (Daucus carota), leek (Allium porrum), radish (Raphanus sativus), rutabaga (Brassica napobrassica), and turnip (Brassica napa).

Salad crops: Endive and escarole (Cichorium endiva), fennel (Foeniculum vulgare), garden cress (Lepidium sativum), lettuce (Lactuca sativa), parsley (Petroselinum hortense), spinach (Spinacea oleracea), Swiss chard (Beta vulgaris, var. cicla), upland cress (Barbarea vulgaris), and water cress (Nasturium aquaticum).

Pulses: Garden peas (Pisum sativum, var. macrocarpon).

151

Cole crops: Broccoli (Brassica oleracea, var. Italica), cabbage (B. oleracea, var. capitata), cauliflower (B. oleracea, var. botrytus), Chinese cabbage (B. pekinesis), collards (B. oleracea, var. acephala), and kale (B. caulorapa).

Warm season possibilities:

Salad crops: Celery (Apium graveolens).

Pulses: Lima beans (Phaseolus limensis), and snap beans (Phaseolus vulgaris, var. humilus).

Solanaceous crops: Eggplant (Solanum melogena), sweet peppers (Capsicum frutensens, var. grossum), and tomato (Lycopersicon esculentum).

Other: Cucumbers and melons (Cucumis species), okra (Hibiscus esculentus), pumpkin and squash (Cucurbita species), and sweet corn (Zea mays, var. saccharata).

Crops that require excessive time for propagation or impose excessively high costs of production include artichoke, asparagus, horseradish, mushrooms, rhubarb, sweet potatoes, and watermelons. Onions and potatoes, now grown in Ethiopia, should not be considered for the Finchaa. Onions (Allium cepa) are adversely affected by temperatures in excess of 21° C. (70° F.). Potatoes (Solanum tuberosum) will not set tubers above 29° C. (84° F.). Since higher temperatures are expected, neither of these crops is suitable.

Fruit, Berries, and Nuts. Fruit production in the Finchaa area is subject to greater restrictions than vegetable growing. The per capita consumption of fruit is even lower than vegetables, and is largely confined to foreign groups, upper income urban Ethiopians, and certain lowland groups. Transportation difficulties, perishability of the products, and a lack of processing facilities would discourage a large export market. Fruit production is generally a long-term project, requiring years before crops can be harvested. And the Finchaa area has certain climatic features which render it unsuitable for many popular types of fruit.

Fruit. Climate of the Finchaa valley, and actually of much of the Blue Nile Basin, is a severe limiting feature. The lack of a pronounced winter season precludes all possibility of temperate trees which require dormancy or rest, and aggregate of heat units is insufficient for maturation of many tropical crops, which would tend to reduce yields. The best solutions are the subtropical plants which will fruit without dormancy or will enter dormancy without freezing temperatures. Furthermore, the effect of the long summer rainy season on subtropical crops should be considered, particularly on imported varieties.

For this reason, propagation of such popular temperate zone fruits as apples, cherries, pears, nectarines, and peaches should not be attempted. Also no plantings of bananas, papaya, dates, breadfruit, mango, pineapple, or other tropical crops should be made. Although bananas are seen even higher in elevation than the Finchaa valley, production is uncertain and yields are low. Furthermore, some subtropical crops which will tolerate some cool weather, including citrus and olives, probably would not yield well here.

Nevertheless, a few fruit crops may be successfully grown in the Finchaa area. Some are known in Ethiopia, but most are not. The European grape (Vitus vinifera) is one of these. Grapes are one of the few fruits consumed in Ethiopia in a variety of forms. The crucial factor concerning vitriculture is the cold and heat requirement. Some varieties of V. vinifera will undergo rest in the absence of freezing temperatures, and still mature a crop. Therefore selection of the proper variety is paramount. Grapes are now being grown in scattered Blue Nile areas.

The fig (Ficus carica) will tolerate a cool dormancy period, so should not suffer from lack of low temperatures during its annual cycle. However, fruiting is retarded both by cool nights and by temperatures below 38° C. (100° F.) in certain seasons.

The litchee or lychee (Litchee chinensis) has been grown in China for centuries along rice paddies and canals to hold the banks in place. The tree is perfectly adapted to tropical uplands. It will neither fruit in hot humid climates nor tolerate heavy frost. It may also be grown as an orchard tree. The edible portion is a fruit which when dried is called "litchee nut."

Litchee requires a perfectly drained soil, and will produce a full crop in seven or eight years. Since the fruit is unknown in Ethiopia, and in view of the long period needed to produce the crop, it may be planted as an ornament or near the project waterways rather than as a commercial crop. If so, it should be evaluated against the eucalyptus, which will produce firewood and make a more rapid growth and which can also be planted along waterways.

The longan or Dragon's eye (Euphoria longan) is a hardy relative of the litchee. This tree may be best utilized in the higher Blue Nile project elevations, where frost is more probable. The fruit is similar to the litchee and the tree has ornamental possibilities, as well as being suitable for planting along waterways.

The loquat (Eriobotrya japonica) is a member of the rose family that is adapted to tropical highlands. It thrives in cool

153

subtropical climates, preferably above 1000 meters, where there is freedom from hard frost and extreme heat. It requires a well-drained clay for best growth, and the fruits are eaten fresh or preserved.

The cherimoya and the ilama (Anona spp.) are related to the genus soursop, the custard apple, and the sugar apple. These last three are tender, but the cherimoya and ilama thrive in tropical uplands on perfectly drained soils. The fruits may be eaten fresh, or crushed and mixed with liquids as a sherbet.

The Japanese persimmon or kaki (Diospyros kaki) will thrive above 1000 meters in the tropics. It must have a well-drained soil. The fruits are consumed fresh or dry.

None of the important citrus fruits (Citrus spp.), including the orange, grapefruit, lime, lemon, and citron, is suitable for commercial propagation in the Ethiopian highlands. Fruiting is retarded by cool temperatures, and the trees prefer a sandy soil with good drainage. However, there are some minor species that have somewhat different requirements. The mandarin or tangerine (Citrus reticulata) will grow up to 1500 meters in the tropics. The kumquat (Fortunella species) and the trifoliate orange (Poncirus trifoliate) will grow even higher. However, the Blue Nile Basin does not show promise as a citrus growing area, and citrus production probably should be confined to certain lowland areas of Ethiopia.

The tree tomato (Solanum betaceum) is a perennial tree related to the common or vine tomato, which produces a tomato-like fruit. It is a hardy plant that requires cool nights, and should grow well in highland tropical areas, such as the Finchaa. Since there already has been some small degree of acceptance of tomatoes in Ethiopia, this crop may be of use. The naranjilla (Solanum quitonse) is another relative of the tomato that is found in the tropical highlands of South America. The fruits may be consumed fresh or used for juice or preserves.

Berries. In view of the very small consumption of berries of any type in Ethiopia, and the difficulties of growing the common varieties in a subtropical climate, berry propagation in the Finchaa valley should not be considered now. Furthermore, berry crops are noted for perishability, and require either immediate transportation to market, or local preserving facilities.

Strawberries (Fragaria chiloensis) require either freezing temperatures during the rest period, or high daytime temperatures if a variety which does not require rest is chosen. Length of day

is important for heavy yields, and nearby marketing or processing facilities are essential. Although crops can be produced in the Blue Nile Basin, yields are not high, and markets are not extensively developed.

Bramble berries, and the Youngberry, Boysenberry, and Loganberry, all Rubus species, which include the red, black, and purple raspberry, the blackberry, and the dewberry, require a dormancy period with cool temperatures.

The currant (Ribis spp.), gooseberry (Ribis uva-crisca), blueberry (Vaccinium spp.), and cranberry (Vaccinium spp.) are nonbramble berries which require much more rigorous winter temperatures than the Finchaa area provides.

Nuts. Few species of nuts are adapted to commercial planting in highland Ethiopia. Many of the major species of tropical origin do not thrive in subtropical or temperate areas. They require high daytime temperatures, warm nights, and absolute freedom from cold weather or frost. Cool nighttime temperatures during the budding and blossoming period are injurious to the reproductive parts of the plant. The temperate zone nuts, on the other hand, require a dormancy period, which would not be provided by the Finchaa area. Furthermore, the strangeness of these crops would be a marketing handicap, and the years required to produce a crop an additional disadvantage.

The Ecuador, Bolivia, and Colombia walnuts (Juglans honorei, J. boliviana, and J. colombiensis), found in highland South America, are slight possibilities. The mu-yu-shu, or mu-yu-oil nut, a relative to the tung nut, is adapted to the tropical highlands. The oil resembles tung oil and is used as a dryer for paints and varnishes.

Probably no nut plantings should be considered for the Finchaa area. However, the project area may be examined for indigenous nuts, as well as for other useful plants.

Fibers. No fiber crops are projected for the Finchaa area. Flaxseed, used for fiber elsewhere, is included only for production of seed. Experiments with fiber flax in 1951 and 1952 indicated that it could be grown in the Ethiopian highlands, but this was never implemented. Commercial equipment for reducing the flax to fiber is not available in the country. Flax is a variety of L. usitatissimum. The stems are straighter and longer, with fewer branches. Only small amounts of seed, of low oil content, are borne.

155

Ramie (Boehmeria nivea) is a subtropical fiber presently found in scattered sections of the Blue Nile highlands. New Zealand flax (Phormium tenax) is a hardy relative of sisal that can be grown only in the subtropics. Hemp, or true hemp (cannabus sativa), is a temperate zone plant that produces the raw material for fiber, but also is the source of the drug marijuana, hashish, or bhang. Hemp might be avoided for this reason. Cabuya (Furcraea cabuya), another hardy relative of sisal, is a Central American plant grown up to 1800 meters.

Many other fibers grown elsewhere require tropical conditions for best growth. Among these are Manila hemp (Musa textiles); dum palm (Phytelephas macrocarpa), found in lowland Eritrea; jute (Corchoris species); kapok (Eriodendron anfractuosum); kenaf (Hibiscus species); sanseviera or bowstring hemp (Sansevieria species); Yucatan sisal or henequen (Agave fourcroydes); and sisal (Agave sisalana). Sisal, however, appears to have a certain tolerance for cooler climates, since it is cultivated in Kenya at 1500 meters.

Cotton (Gossypium species), the major world vegetable fiber, prefers an elevation in Ethiopia not greater than 1000 meters. Although perennial forms may be seen much higher, yields are extremely low by commercial standards, maturity is delayed by cool weather, and losses by disease and insects are increased by late maturity. At present, cotton growing schemes are being conducted in several lowland Ethiopian areas.

False banana (Musa ensete) deserves special mention. It is an indigenous relative of the true banana, and has been cultivated in Ethiopia for centuries. The greatest use is the starchy pseudostem as a dietary staple, and the pseudostem and leaves yield a fibrous strand. At one time false banana was an important highland crop, but with the shift of population the plant has been pushed farther south. Growth is better in the lower, warmer areas.

Stimulants and Spices. Coffee, tobacco, and hot peppers are projected for the Finchaa area. However, there are many possible alternatives.

Khat or chat (Catha edulis) is a perennial indigenous shrub cultivated in many parts of Ethiopia. The leaves and young twigs are chewed for a stimulating effect. Possible detrimental effects are suffered by the user, and khat is a habit-forming narcotic. Several neighboring countries have banned the import of Ethiopian khat, and the khat trade is frowned upon by the World Health Organization. Therefore, no khat is projected for the Finchaa or any other Blue Nile project.

Tea (Thea sinensis) is a subtropical shrub with doubtful application for the Finchaa valley. The long cloudy summer, the spring rains, and nighttime temperatures below 13° C. (55° F.) would reduce yields. Tea also requires a processing plant nearby to receive the leaves, or else a more distant plant with air service to the project.

Gesho or buckthorn (Rhammus prinoides), a substitute for hops, is used in brewing beer. It is a small perennial shrub found wild in the Ethiopian highlands.

Peppers are the only spice included in the cropping projection. Many spices, however, are consumed in the Ethiopian diet, and some of these might be included if more data were available regarding their production, growth, and yields. However, the scantiness of information, the small scale, and the simple methods of cultivation make the response of any given spice to modern, irrigated farming impossible to predict. Therefore, spices now important in the diet should be tested on the project experimental farm before field plantings are considered. Important Ethiopian spices include anise (Pimpinelle anisum); black cumen (Nigella sativa), caraway (Carum carvi), cardamon (Elettaria cardamonium), coriander (Coriandrum sativum), dill (Anethum graveolens), lemongrass (Andropogon citratus), marjoram or oregano (Origanum marjorana), and tumeric (Curcuma longa).

Ethiopia uses a great variety of spices, including many not mentioned above, but her production does not suffice for her needs. Net spice imports have increased yearly, and in 1960/61 were Eth$609,000. Therefore the marketability of accepted spices is assured, in contrast to future plantings of fruit, vegetables, or nuts.

Care must be taken to insure that the spices tested on the experimental farm are adapted to subtropical conditions. Spices adapted only to tropical conditions include black and white pepper, cloves, ginger, nutmeg or mace, and pimento.

Medicinal and Essential Oil Plants. A large number of potentially valuable plants whose oily exudations or secretions are used for medicine, perfumes, flavoring, or lubrication are found in Ethiopia, either cultivated or in the natural state. Here again the cultivation is small and data are lacking. These plants are utilized in their crude state, but the finished products of many are imported into Ethiopia in more expensive, compounded forms. Accordingly some may deserve testing, for consideration in future cropping patterns.

The best known medicinal plants found in Ethiopia today are foxglove (Digitalis species), the source of digitalis; saffron (Crocus sativus); senna (Cassia species); thorn apple (Datura stratomium); and wild rose or hip (Rosa canina). A drug not grown in Ethiopia but an important cash crop in highland Kenya is pyrethum (Chrysanthenum species).

Essential oil plants found in highland Ethiopia, many of which have pharmaceutical, food processing, or industrial usage include peppermint, spearmint, and pennyroyal (Mentha piperita, M. crispa, and M. virdiris); and thyme (Thymus species). The oil of the Ethiopian eucalyptus (Eucalyptus globulus) is used abroad but is not extracted in Ethiopia.

Many common Ethiopian plants produce useful oils in their leaves, stems, or blossoms, including the carnation, daffodil, elder, geranium, heliotrope, honeysuckle, iris, lavender, lilac, lily, narcissus, patchouli, rosemary, sweet pea, tuberose, violet, and wall flower. Most of these are common temperate zone flowers.

Before commercial planting of essential oil plants is made on the Finchaa or other projects, the establishment of a rendering or extracting plant must be considered, or else export possibilities studied.

Firewood. A persistent problem in Ethiopia has always been the procurement of an adequate supply of firewood. The eucalyptus, since its introduction, has been a partial solution; where it is planted the available supply of firewood is always increased. The Finchaa Project will face the problem of fuel for cooking and heating. If electric power is not suitable for domestic use in the Finchaa area, and since fossil fuels are expensive in Ethiopia, the eucalyptus may be the answer here, too.

No land is specifically allotted to coppices of trees. However, five percent of the irrigable land is projected for the farm house and lot, farm roads, and ditches. A portion of this might be planted in eucalyptus, to supply fuel after the wood and vegetative debris cleared from new lands has been exhausted. Several years are required before firewood can be harvested economically from coppices.

Another possibility is the planting of trees along portions of the irrigation canals. Species mentioned earlier include the litchee, longan, and loquat. Other possibilities, either along the waterways or in coppices, are the newly introduced pines, cypresses, and Australian acacia. This question should be considered in detail in the final Finchaa study, in cooperation with the Ethiopian Forestry Association.

Livestock

The integration of livestock with irrigated farming in the Finchaa Project area poses a set of problems that are probably best avoided in the beginning years of project operations. The inclusion of livestock means careful attention to breeding programs, disease control and eradication, maintenance of grain and forage supplies, and development of markets for profitable turnover of livestock and products. These problems are not always solved successfully under conditions where quality stock is produced, markets are established, heavy per capita meat consumption exists, adequate transportation facilities are available, fodder reserves are ample, and where diseases and pests have been brought under control. But in Ethiopia, major problems exist in each of these phases of the livestock production and marketing cycle. Moreover, enormous areas outside the Blue Nile Basin could be developed for livestock production on a nonirrigated basis. Portions of the Awash valley and of the vast semiarid area southeast or south of Addis Ababa can produce livestock on an extensive basis. Some of these areas are served by rail transport both to Addis Ababa and to the port of Djibouti on the Red Sea. Therefore consideration of livestock has been excluded on a commercial basis from the Finchaa and the other Blue Nile irrigation projects, for the immediate present.

This need not mean that livestock must be entirely absent from the project area. The Ethiopian farmer is accustomed to having a few head of livestock on hand, and he counts his wealth partly in animals. It is recommended that the project population be allowed to keep some livestock as personal possessions, partly as a concession to their conservative outlook, and partly because there will always be some waste areas, such as nonarable land, land along fence rows, irrigation ditches and canals, and in villages, where cattle, sheep, or goats can be grazed at no cost to the project. Furthermore, the milk and meat produced would be nutritious supplements to the basic foodstuffs the project will raise. The number of head must be supervised to prevent overgrazing of the available pasturage. Rules concerning ownership per family should be formulated in advance of project operations.

Land Settlement

At the present moment, the Finchaa valley is uninhabited. With the commencement of project operations as much as 640 hectares will be immediately developed, and population settled on this land. This will require about 608 farmers and workers, excluding managerial and service personnel, and excluding the irrigable land required for farm houses, roads, and woodlots. Applying the average family size of 4.7 members, approximately 2,800 people can move into the Finchaa Project area and find land and work.

Under ultimate development, the entire 15,000 hectares of irrigable land should be occupied. This will offer settlement opportunities to over 65,000 farm people (see SECTION IX), plus others required for management, operation and maintenance, and extension. In addition, many service workers will be drawn into the area.

AMARTI-NESHE PROJECT

The land classification and agricultural economics of the Amarti-Neshe Project are essentially the same as the Finchaa Project. The Amarti-Neshe Project is smaller, however, so crop production will be less. Therefore only the summary sheets, which reflect the differences in size, are shown separately. The discussion of agricultural conditions before project development, agricultural conditions after agricultural development, and land settlement would be covered under the Finchaa Project.

Tables VI-7 and VI-8 are designed to show the agriculture of the Amarti-Neshe Project in terms of crop production and of gross income to be realized by the project from the sale of crops. Table VI-7 shows the production on the basis of 100 hectares, and Table VI-8 on a full project, 8,490-hectare basis. These tables are identical to the Finchaa Project summary sheets in all but one respect. Total gross crop income for the Finchaa is $8,932,130; for the Amarti-Neshe it is $5,061,975.

The consumption of food will follow a similar pattern for the Amarti-Neshe as the Finchaa Project. Total yearly production of calories will be approximately 81,000,000,000; of this, 33,000,000,000 will be consumed on the project and the remainder sold.

TABLE VI-7 . Summary of Farm Income for Estimating Benefits by Use of the Cross Crop Income Method, Amarti-Weshe Project, Ethiopia, on a Full Project, 8,490-hectare Basis

CROP PATTERN	CONDITIONS BEFORE PROJECT: CROP DISTRIBUTION 1/ ha	YIELD Kg/ha	PRODUCTION Kg	PRICE RECEIVED PER 100 Kg Eth.$	INCOME Eth.$	FUTURE CONDITIONS, IRRIGATION SEASON: CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	SHIPMENT TO CENTRAL MARKET Kg	VALUE OF SHIPMENT TO CENTRAL MARKET Eth.$	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth.$	FUTURE CONDITIONS, NONIRRIGATION SEASON: CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth.$		TOTAL INCOME Eth.$	INCREMENTAL INCOME Eth.$
Buckwheat	-			9.60		425	2,000	850,000	636,750	61,130	213,250	20,470	-	-	-	-	-		81,600	81,600
Corn	-			10.18		1,275	3,175	4,048,125	3,550,940	361,485	497,185	50,610	2,550	1,180	3,009,000	3,009,000	305,315		717,410	717,410
Millet (dagussa)	-			9.90		-	-	-	-	-	-	-	2,120	975	2,067,000	2,067,000	204,635		204,635	204,635
Sorghum	-			13.70		1,700	2,980	5,066,000	3,070,850	420,705	1,995,150	273,335	-	-	-	-	-		694,040	694,040
Haricot beans	-			16.52		850	1,780	1,513,000	1,513,000	249,950	-	-	850	950	807,500	807,500	133,400		383,350	383,350
Flaxseed	-			21.14		425	1,000	425,000	425,000	89,845	-	-	-	-	-	-	-		89,845	89,845
Mustard	-			7.75		425	1,170	497,250	497,250	88,260	-	-	850	700	595,000	595,000	105,610		193,870	193,870
Castor beans	-			26.62		850	2,000	1,700,000	1,700,000	452,540	-	-	-	-	-	-	-		452,540	452,540
Sunflower	-			25.60		850	1,800	1,530,000	1,530,000	391,680	-	-	-	-	-	-	-		391,680	391,680
Coffee	-			161.84		425	960	408,000	348,090	563,350	59,910	96,960	425	-		-	-		660,310	660,310
Peppers	-			55.93		425	920	391,000	178,290	99,720	212,710	118,970	-	-	-	-	-		218,690	218,690
Tobacco (Oriental)	-			114.60		425	2,000	850,000	850,000	974,100	-	-	-	-	-	-	-		974,100	974,100
Subtotal, Crops	-					8,075				3,752,765		560,345	6,795				748,960		5,062,070	5,062,070
Fallow	-					-				-		-	1,260				-			-
Subtotal, Cultivated area	-					8,075				3,752,765		560,345	8,070				748,960		5,062,070	5,062,070
Noncultivated irrigable land	8,490					415				-		-	415				-			-
Total area	8,490					8,490				3,752,765		560,345	8,490				748,960		5,062,070	5,062,070

1/ This project area is uninhabited at present.

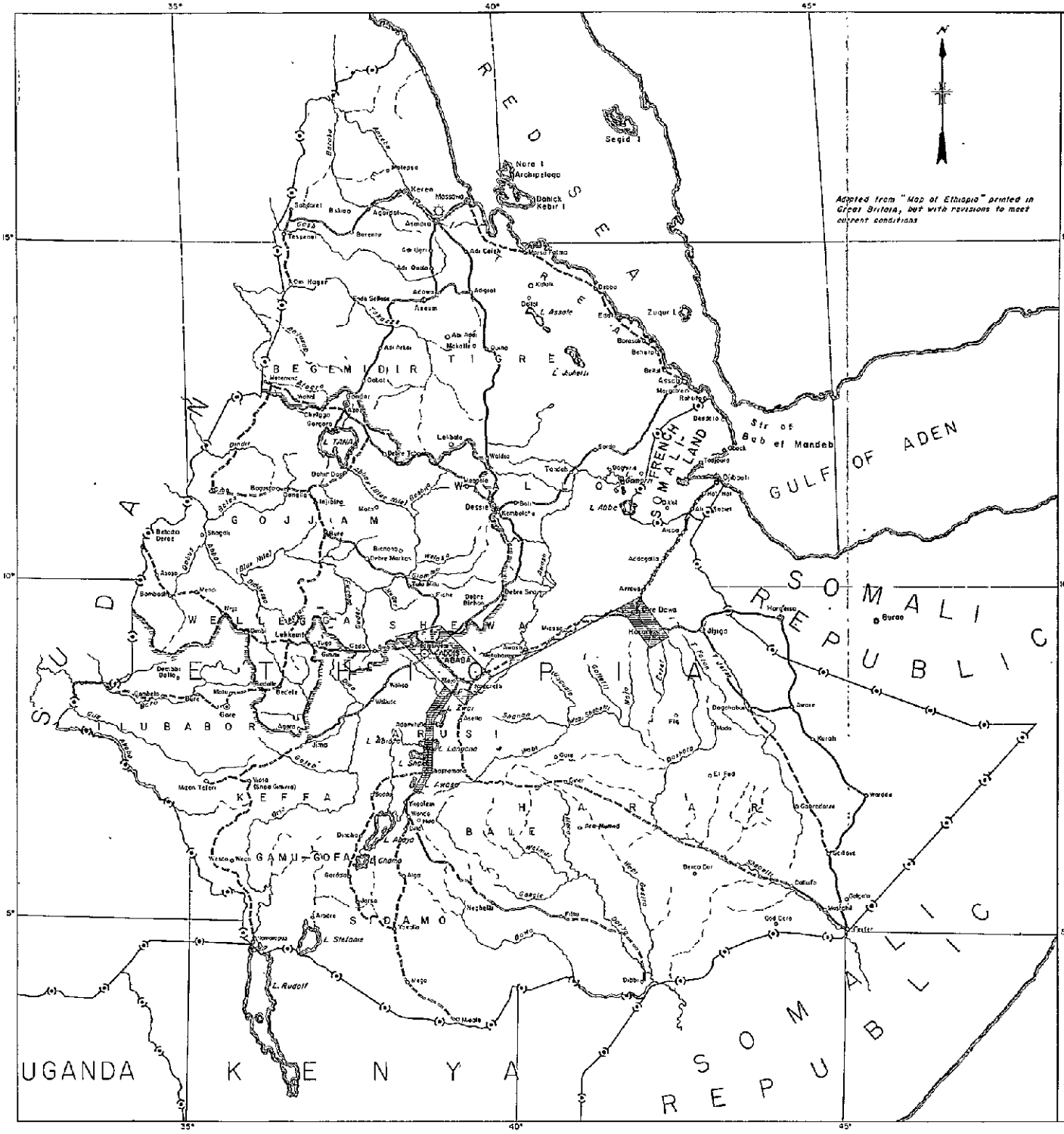
161 161A 161B 161C

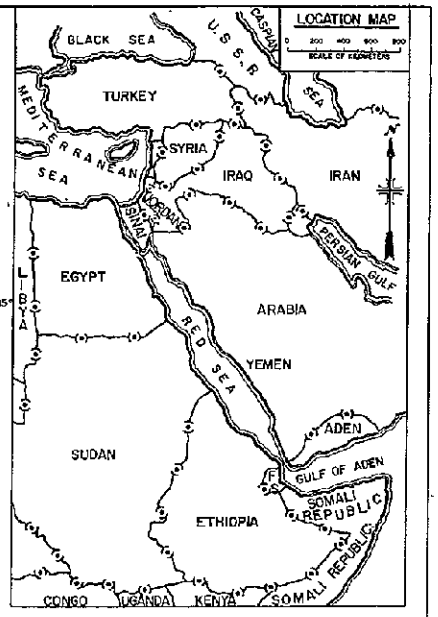
TABLE VI-8 . Summary of Farm Income for Estimating Benefits by Use of the Gross Crop Income Method, Awarti-Weshe Project, Ethiopia, on a 100-hectare Basis

CROP PATTERN	CONDITIONS BEFORE PROJECT					FUTURE CONDITIONS, IRRIGATION SEASON							FUTURE CONDITIONS, NONIRRIGATION SEASON						TOTAL INCOME	INCREMENT INCOME
	CROP 1/ DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	PRICE RECEIVED PER 100 Kg Eth $	INCOME Eth $	CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	SHIPMENT TO CENTRAL MARKET Kg	VALUE OF SHIPMENT TO CENTRAL MARKET Eth $	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth $	CROP DISTRIBUTION ha	YIELD Kg/ha	PRODUCTION Kg	LOCAL CONSUMPTION Kg	VALUE OF LOCAL CONSUMPTION Eth $		Eth $	Eth $
Buckwheat	-			9.60		5	2,000	10,000	7,500	$ 720	2,500	$ 240	-	-	-	-	$ -		$ 960	$ 960
Corn	-			10.18		15	3,175	47,625	41,825	4,258	5,800	590	30	1,180	35,400	35,400	3,604		8,452	8,452
Millet (dagusse)	-			9.90		-	-	-	-	-	-	-	25	975	24,375	24,375	2,413		2,413	2,413
Sorghum	-			13.70		20	2,980	59,600	36,100	4,946	23,500	3,219	-	-	-	-	-		8,165	8,165
Haricot beans	-			16.52		10	1,780	17,800	17,800	2,941	-	-	10	950	9,500	9,500	1,569		4,510	4,510
Flaxseed	-			21.14		5	1,000	5,000	5,000	1,057	-	-	-	-	-	-	-		1,057	1,057
Mustard	-			17.75		5	1,170	5,850	5,850	1,038	-	-	10	700	7,000	7,000	1,242		2,280	2,280
Castor beans	-			26.62		10	2,000	20,000	20,000	5,324	-	-	-	-	-	-	-		5,324	5,324
Sunflower	-			25.60		10	1,800	18,000	18,000	4,608	-	-	-	-	-	-	-		4,608	4,608
Coffee	-			161.84		5	960	4,800	4,100	6,635	700	2,133	5	-	-	-	-		7,768	7,768
Peppers	-			55.93		5	920	4,600	2,100	1,175	2,500	1,398	-	-	-	-	-		2,573	2,573
Tobacco (Oriental)	-			114.60		5	2,000	10,000	10,000	11,460	-	-	-	-	-	-	-		11,460	11,460
Subtotal, Crops	-					95				44,162		6,580	80				8,828		59,570	59,570
Fallow	-					-				-		-	15				-			
Subtotal, Cultivated area	-					95				44,162		6,580	95				8,828		59,570	59,570
Noncultivated irrigable land	100.0					5				-		-	5				-		-	-
Total area	100.0					100				44,162		6,580	100				8,828		59,570	59,57

1/ This project area is uninhabited at present.

162 162a 162b





EXPLANATION

- Perennial river & stream
- Seasonal river & stream
- International boundary
- Principal airport
- Blue Nile Irrigation boundary
- Primary all-weather roads
- Primary dry-weather roads
- Railroad
- Swamp Area
- Addis Ababa Load Center Complex

35 0 35 70 105 140 175
SCALE OF KILOMETERS

CASE A

MAP OF ETHIOPIA
SHOWING
ELECTRIC POWER LOAD CENTER
ADDIS ABABA COMPLEX

Feb 28, 1963

4 O-BN-169

Assab is located nearly at sea level, and its precipitation is less than 250 mm per year. It has a hot climate with the average maximum around 28° C and the average minimum probably around 20° C.

Population

A complete census has never been taken of the country. See SECTION II, General Description. A recent census was taken in Addis Ababa and is reflected in Table VII-1.

TABLE VII-1 - ESTIMATED 1961 POPULATION BY CITIES

City or Town	Population
Dessie	35,000
Dire Dawa	40,000
Jima	35,000
Agere Hiywet (Ambo)	10,000
Assab	9,000
Lekkemt	25,000
Addis Ababa	450,000

The Blue Nile River Basin (portions of it lie in seven provinces) was estimated to have a population of about 4,870,000 (see Table VII-2).

TABLE VII-2 - POPULATION FOR BLUE NILE RIVER BASIN BY PROVINCES IN THE BASIN--1961

Province	Population (millions)
Wellegga	1.27
Gojjam	1.18
Shewa	1.09
Wello	0.64
Begemidir	0.45
Ilubabor	0.15
Kefa	0.09
Total	4.87

By comparison, the estimates by provinces for Ethiopia as a whole are shown in Table VII-3.

The size of the present population in the Finchaa and Amarti-Neshe project areas is negligible.

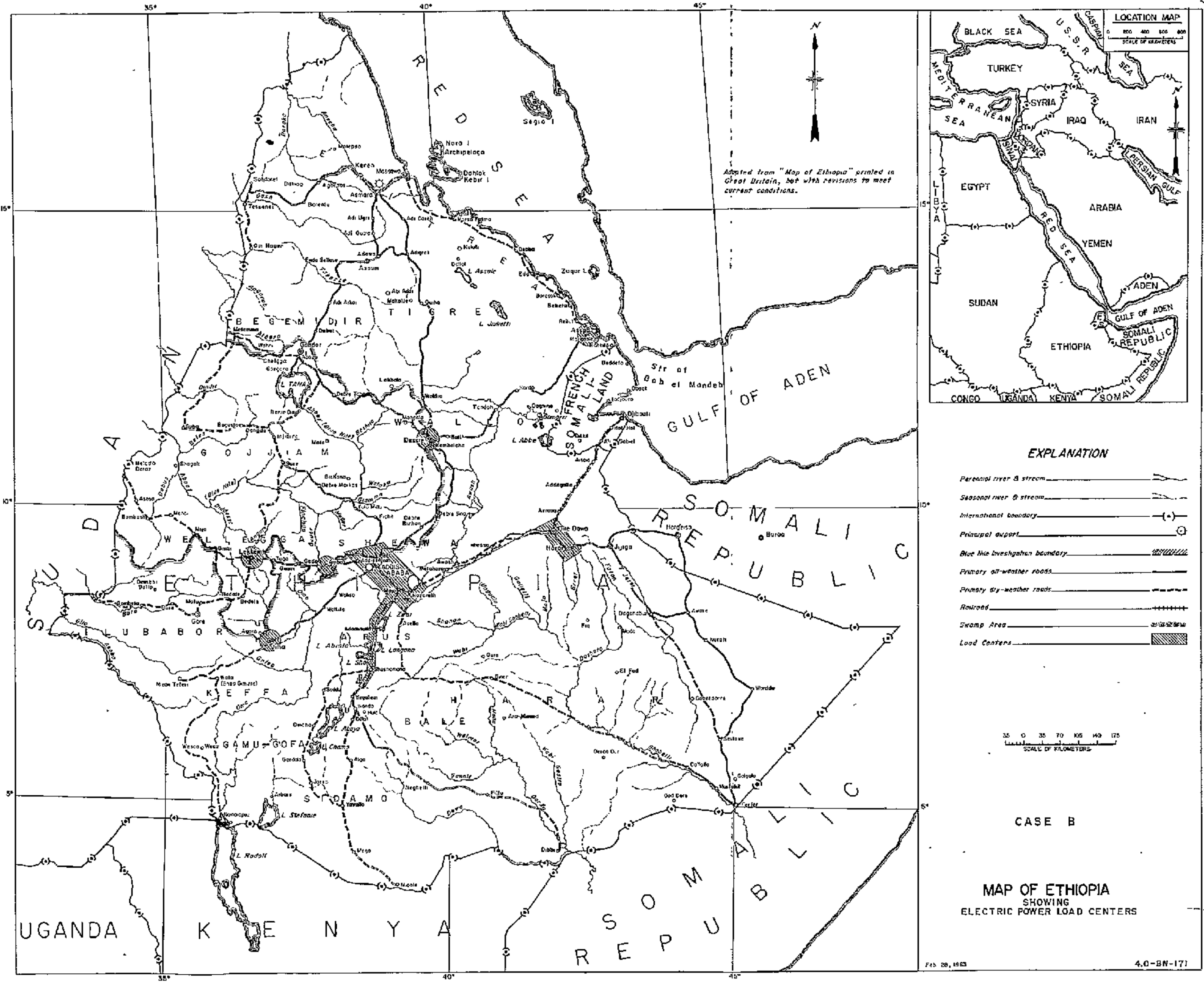
The fastest growing area in the Empire appears to be Addis Ababa, but for the country as a whole, it is believed that the trend in estimated annual population growth may be as shown on Drawing No. 4.0-BN-39.

TABLE VII-3 - 1961 POPULATION ESTIMATES--ETHIOPIA

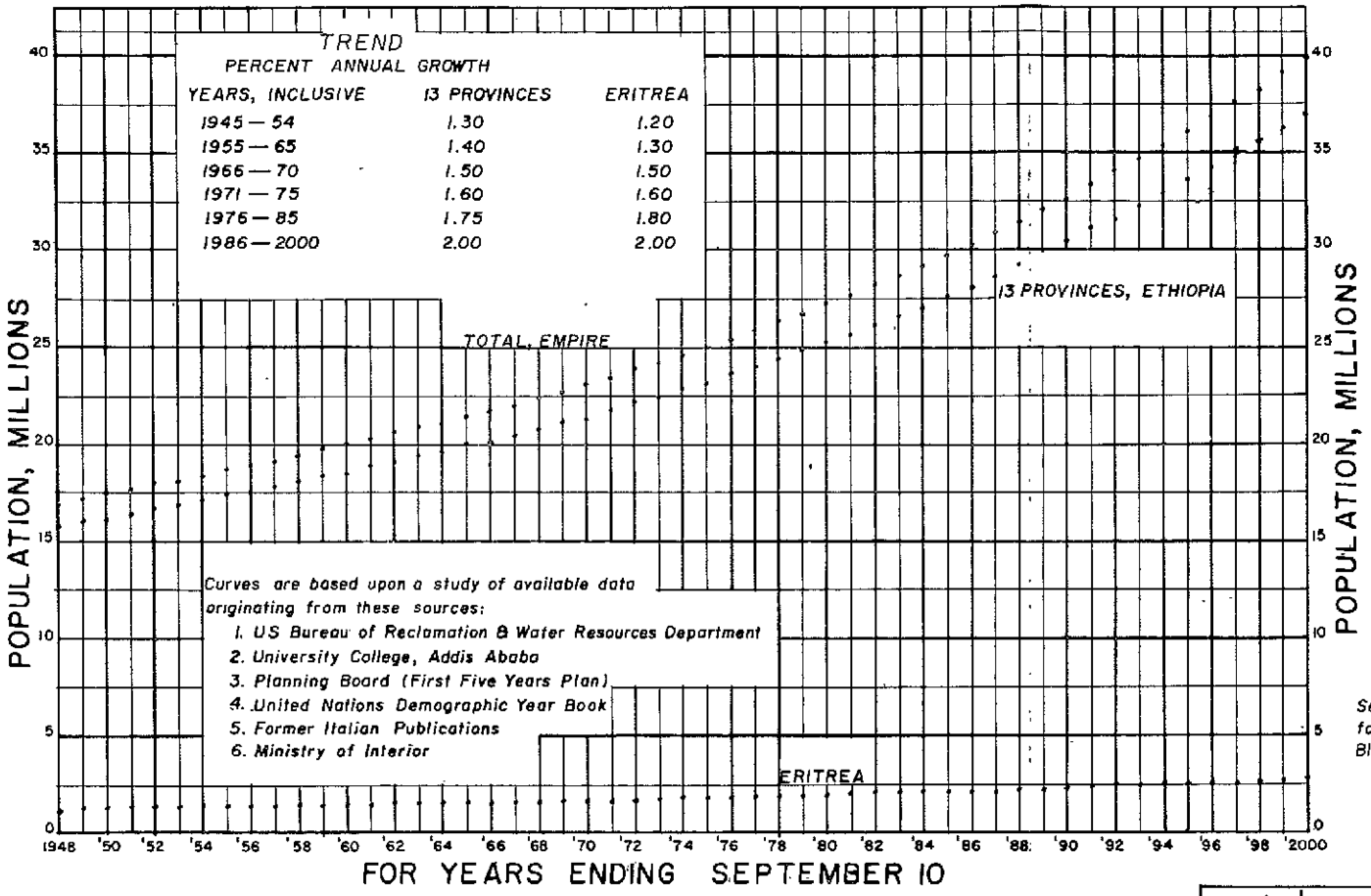
Province	Population (millions)
Tigre	2.59
Wello	2.46
Shewa (w/o Addis Ababa)	2.18
Wellegga	1.73
Sidamo	1.87
Begemidir	1.77
Harar	1.28
Gojjam	1.18
Arusi	.91
Ilubabor	.88
Kefa	.73
Gemu Gofa	.47
Bale	.29
Eritrea	1.46
Provinces	19.80
Addis Ababa	.45
Total Empire	20.25

Occupations of Labor

Some sources place the portion of the population under 15 years of age at 35 percent in Ethiopia. The population portion over 60 was taken at eight percent. On this basis, the assumed portion of population of working age in Ethiopia (15 to 60 years of age) amounts to about 57 percent. If the upper limit of 60 years were dropped to 56 years--in other words, the working age would be from 15 to 56 years--the percentage of people of working age would



LOCATION MAP
BLACK SEA
U.S.S.R.
CASPIAN SEA
TURKEY
MEDITERRANEAN SEA
SYRIA
IRAQ
IRAN
JORDAN
SINAI
PERSIAN GULF
EGYPT
LIBYA
ARABIA
YEMEN
ADEN
GULF OF ADEN
SUDAN
ETHIOPIA
SOMALI REPUBLIC
CONGO
UGANDA
KENYA
Adapted from "Map of Ethiopia" printed in Great Britain, but with revisions to meet current conditions.
RED SEA
GULF OF ADEN
Str of Bab el Mandeb
FRENCH SOMALI LAND
SOMALI REPUBLIC
SUDAN
ETHIOPIA
UGANDA
KENYA
BEGEMDIR
TIGRE
ERITREA
WOLLO
GOJJAM
WELLEGA
SHEWA
LUBABOR
ARUSSI
KEFFA
GAMU-GOFA
SIDAMO
BALE
HARAR
ADDIS ABABA
Asmara
Massawa
Keren
Gondar
L. TANA
Dessie
Assab
Djibouti
Dire Dawa
Harar
Jijiga
L. Rudolf
L. Stefanie
L. Abbe
EXPLANATION
Perennial river & stream
Seasonal river & stream
International boundary
Principal airport
Blue Nile Investigation boundary
Primary all-weather roads
Primary dry-weather roads
Railroad
Swamp Area
Load Centers
SCALE OF KILOMETERS
CASE B
MAP OF ETHIOPIA
SHOWING
ELECTRIC POWER LOAD CENTERS
Feb 28, 1963
4.0-BN-171



See Drawing No. 4.0.-BN-29 for Population Density of Blue Nile River Basin.

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST. AGENCY FOR INT. DEV. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

ESTIMATED POPULATION TREND

DRAWN C.L. Curtis SUBMITTED C.L.C.
TRACED Assefa, Aebagre RECOMMENDED P.W.K.
CHECKED C.L.C.-S.V.J. APPROVED C.E.B.

Addis Ababa Ethiopia | MAY 30,62(I.C.) | 4.0—BN—39

drop to 54.5. Table VII-4 provides some information on the age structure in Ethiopia as compared with several other countries.

TABLE VII-4 - ESTIMATED AGE STRUCTURE IN ETHIOPIA COMPARED WITH DATA FOR SOME OTHER COUNTRIES 1/

Country	Percentage of population below 15 yrs	Percentage of population over 60 yrs	Percentage of working population 15 - 60 yrs	Percentage of working population 15 - 55 yrs
Ethiopia	35	8	57	54.5 2/
Ghana	36.6	5.4	58	-
Southern Rhodesia	27.4	8.7	63.9	-
Turkey	39.6	6.2	54.2	-
England	15.5	11.8	71.7	-
U.S.A.	20.1	11.7	69.2	-

1/From United Nations Demographic Yearbook, 1951.
2/The population between 55 and 60 years is assumed to be 3.5 percent.

Considering the country as a whole, over 90 percent of the population is engaged in agricultural pursuits. The other 10 percent can be considered as supplying the labor needs of government, commercial and industrial enterprises, and various miscellaneous categories. In the 10 percent group would fall the labor employed in urban areas. By far the largest urban area, of course, is Addis Ababa, and according to the Ministry of Commerce and Industry, in 1960 there were about 60,500 persons gainfully employed in the city. Percentagewise, this labor force was distributed as follows:

Domestic service	24.75 percent
Civil service (Government)	21.50
Commerce	17.25
Manufacture	15.00

Drawing No. 4.0-BN-40 gives an indication of those employed in various types of industries in the 13 provinces, and perhaps 75 percent of those shown are located in the Addis Ababa Complex. In the Blue Nile River Basin, as shown by examining Drawings No. 7.2-BN-1 and 4.0-BN-29, the predominantly agricultural areas having the greatest population density occur along the northern and northeastern

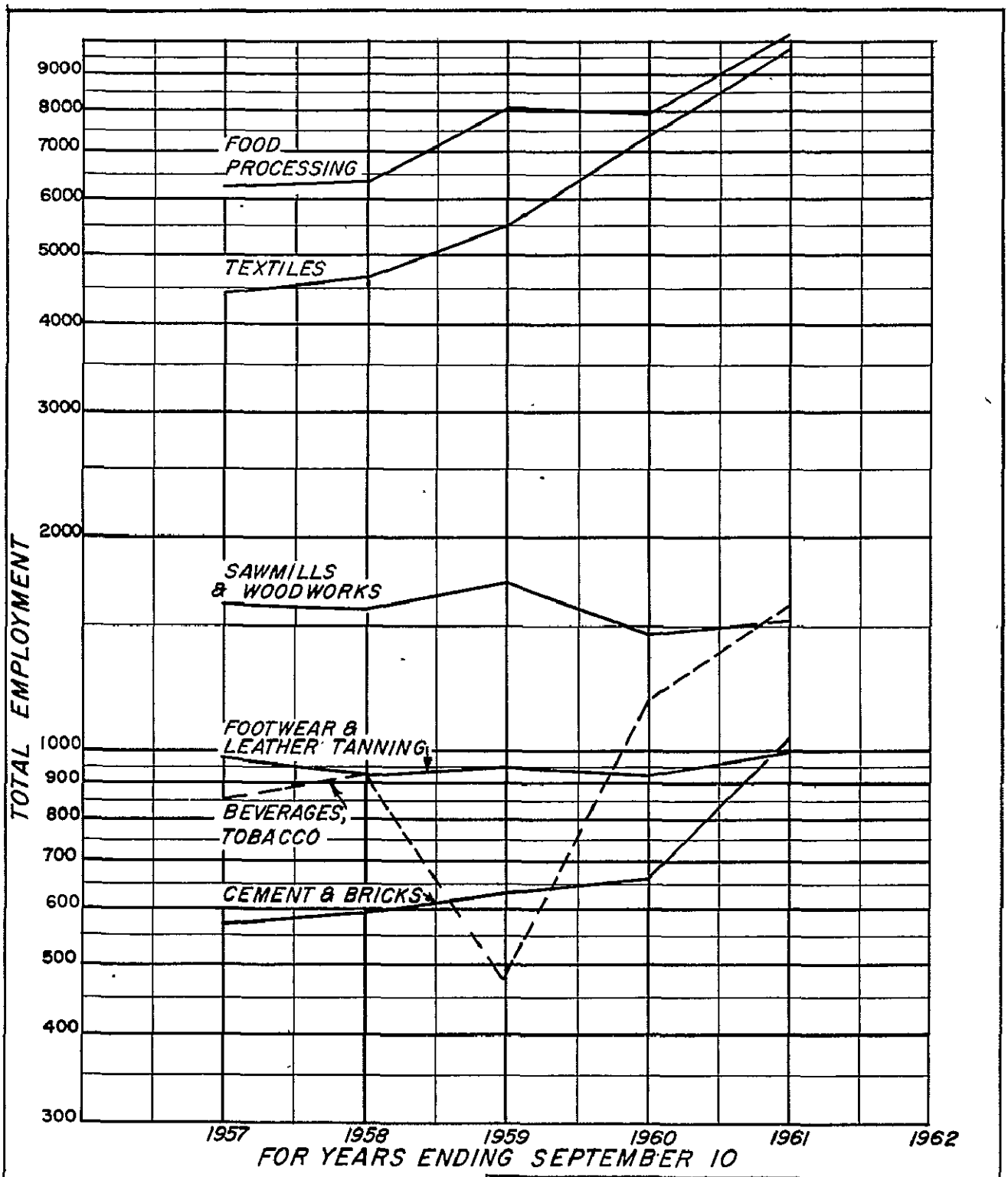
168

sides of Lake Tana, along the Bahir Dar-Addis Ababa highway, and along the inside loop of the Blue Nile River on the highlands. Many of these agricultural areas, which are located in the heavy population zone, are nearly saturated now, relative to the number of people that the land can support with a decent standard of living. Therefore, it is reasonable to expect that while the heavily populated areas will remain substantially static, new areas will have to be opened up for agricultural purposes and the development of new industry will be required to provide jobs for the remaining excess population.

Regarding the future labor force in Ethiopia, some general conclusions can be reached. Based upon a 1960 population of about 20,000,000 in the Empire, including Eritrea, the population will probably double to 40,000,000 by the year 2000. As stated before, the present labor force is 90 percent engaged in the agricultural industry. With the trend toward urbanization and correlary development of industry that is anticipated by the year 2000, some authorities conservatively estimate that 65 to 70 percent of the population will, at that time, be engaged in agricultural activities. This means that the present 10 percent of nonagricultural occupations will increase to at least 30 to 35 percent by the year 2000. On this basis, the rate of increase for nonagricultural jobs would average around 150,000 to 170,000 jobs per year. On the other hand, the rate of increase in agricultural jobs would be about 500,000 per year. The opening up of new lands to farmers by appropriate redistribution, by controlling diseases and other problems in certain undeveloped locations, and by providing water and power from multipurpose projects in still other areas will generally take care of the anticipated annual rate of increase in agricultural fields. But the rate of increase in the nonagricultural fields will have to be provided for in industry, and industry needs electric power in abundant and economical quantities. It is apparent that a reservoir of labor is available for industrial expansion.

Natural Resources

Ethiopia's greatest resource is its land, which is and can be used for agricultural purposes. Using the F.A.O. figures on percentage distribution, the land-use estimates in Table VII-5 are derived.



NOTES

1. Source: Ethiopian Economic Review 1-5
2. Excludes: Smaller miscellaneous Industries
3. Excludes: Eritrea — 13 Provinces only

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF STAGENCY FOR INT DEV. AND U.S. DEPT. OF INT., BUR. OF RECL

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

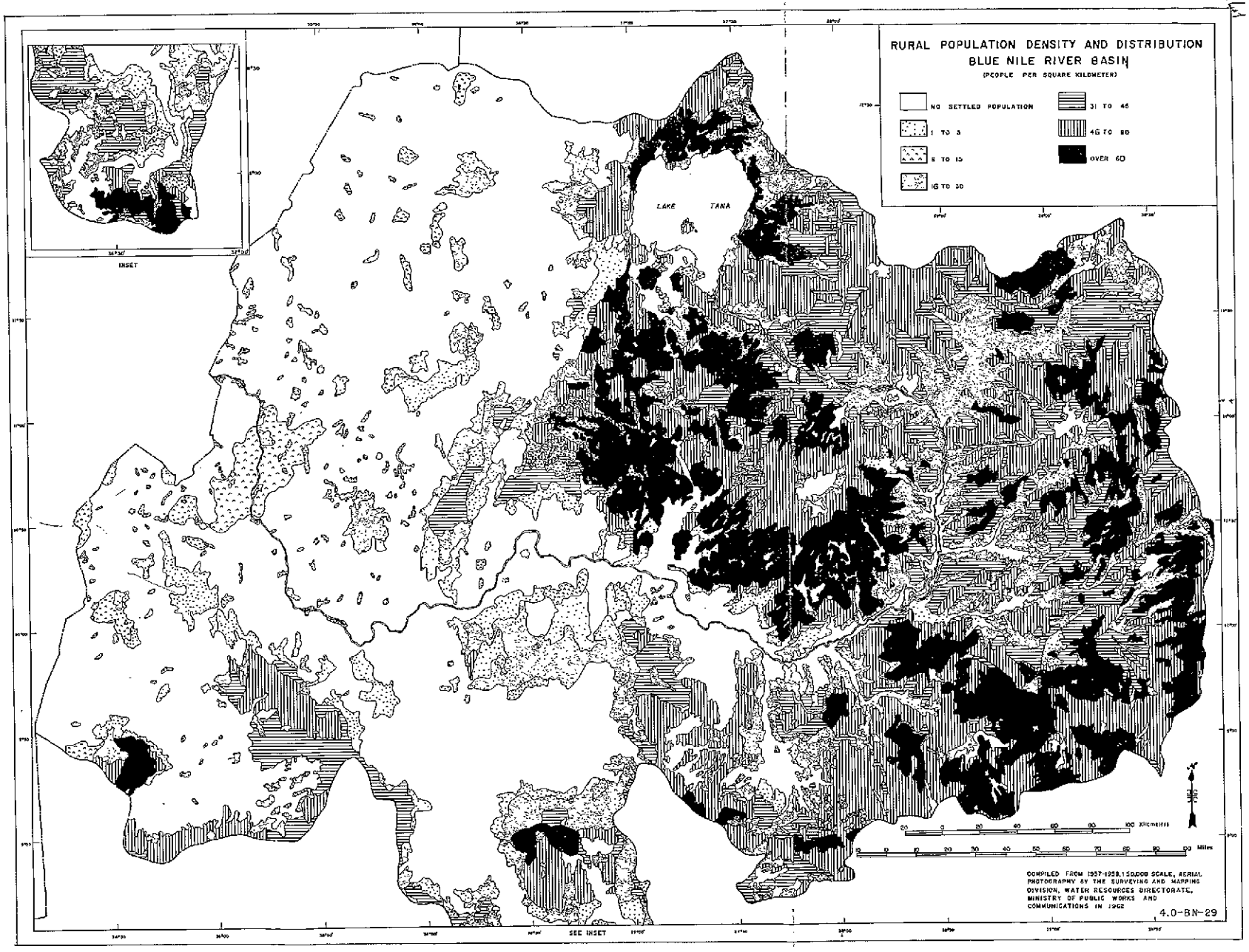
EMPLOYMENT

MANUFACTURING INDUSTRIES

DRAWN C.L. CURTIS
TRACED MASRESHA
CHECKED C.L.C.
SUBMITTED C.L.C.
RECOMMENDED P.W.K.
APPROVED C.L.C.

Addis Ababa Ethiopia JUNE 1, 1962 | 4-O-BN-40

170


RURAL POPULATION DENSITY AND DISTRIBUTION
BLUE NILE RIVER BASIN
(PEOPLE PER SQUARE KILOMETER)
NO SETTLED POPULATION
1 TO 5
5 TO 15
15 TO 30
31 TO 45
45 TO 60
OVER 60
LAKE TANA
INSET
SEE INSET
Kilometers
Miles
COMPILED FROM 1957-1959, 1:50,000 SCALE, AERIAL PHOTOGRAPHY BY THE SURVEYING AND MAPPING DIVISION, WATER RESOURCES DIRECTORATE, MINISTRY OF PUBLIC WORKS AND COMMUNICATIONS IN 1962
4.0-BN-29

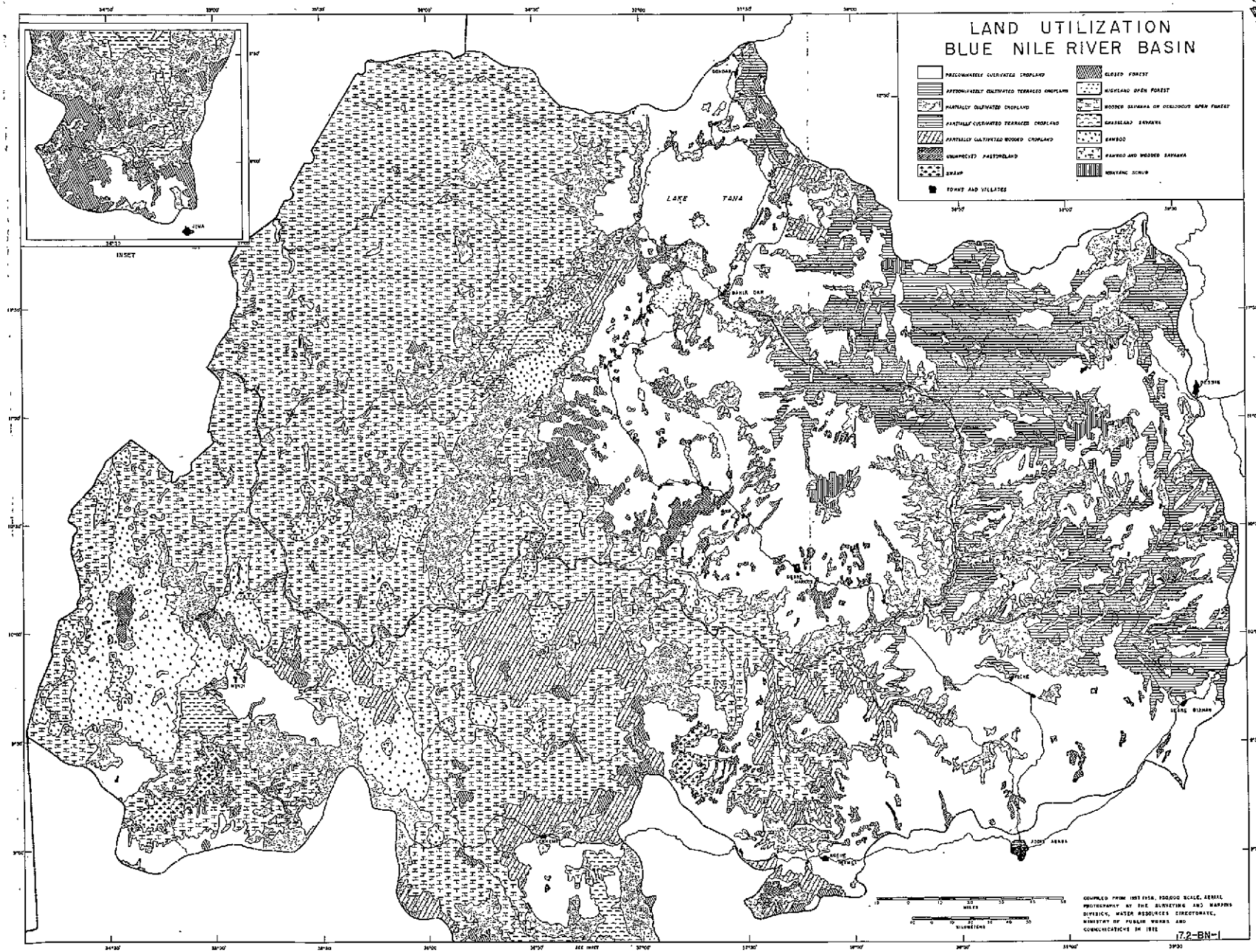

LAND UTILIZATION
BLUE NILE RIVER BASIN
PRECOMPLETELY CULTIVATED CROPLAND
PRECOMPLETELY CULTIVATED TERRACED CROPLAND
PARTIALLY CULTIVATED CROPLAND
PARTIALLY CULTIVATED TERRACED CROPLAND
PARTIALLY CULTIVATED WOODED CROPLAND
UNIMPROVED PASTURELAND
SWAMP
TOWNS AND VILLAGES
CLOSED FOREST
HIGHLAND OPEN FOREST
WOODED SAVANNA OR DECIDUOUS OPEN FOREST
GRASSLAND SAVANNA
BAMBOO
BAMBOO AND WOODED SAVANNA
MONTANE SCRUB
LAKE TANA
BAHIR DAR
GONDAR
DESSIE
DEBRE BIRHAN
ADDIS ABABA
JIMA
INSET
MILES
KILOMETERS
COMPILED FROM 1957-1958, 250,000 SCALE, AERIAL PHOTOGRAPHY BY THE SURVEYING AND MAPPING DIVISION, WATER RESOURCES DIRECTORATE, MINISTRY OF PUBLIC WORKS AND COMMUNICATIONS IN 1972
17.2-BN-1

TABLE VII-5 - LAND-USE AREAS

Land use	F.A.O. 1/ estimates (percent)	Hectares using F.A.O. percentages
Permanent meadows and pastures	49.59	60,499,800
Cultivated	9.70	11,834,000
Potentially productive	7.30	8,906,000
Forested	3.56	4,331,000
Wasteland	29.85	36,429,200
Totals	100.00	122,000,000

1/As reported in Ethiopian Observer, Volume V, No. 2.

The irrigable areas of the Finchaa and Amarti-Neshe Projects total 23,490 hectares and would eventually supply agricultural products for industrial processing, probably in Addis Ababa. This would be an example of "potentially productive" land placed into production and represents two potential power load possibilities--need for electricity by the new project farmers and need for electricity at Addis Ababa, for example, to process certain agricultural commodities.

There are good natural forest areas within reach of the Jima and Addis Ababa Complex load centers. The internal lumber market,* shows a present annual capacity of 40,000 cubic meters. With the rate of annual increased requirements being about 15 percent, the market requirements would be about 70,000 cubic meters within five years. At present, there are 22 major sawmills, and to meet the rising demand for wood products this number would have to be gradually enlarged, which factor must be considered in the power market analysis, as electricity is an economical source of energy for operating these mills. (At present, there is only one large mill, that at Ambo, in the Blue Nile River Basin.) There is now only one plywood factory, at Addis Ababa, and in order to meet the immediate needs of the country, two or three more such veneer mills will be required, processing about 50,000 cubic meters of veneer logs per year. Bamboo thickets cover several thousand

*Includes all imports as well as domestic production, whereas data included under "Development of Electric Energy Use" refer only to internal development, the only pertinent segment that concerns electric energy requirements.

hectares which may be within economical transportation distance of Jima, Addis Ababa, and Lekkemt. Bamboo is useful for the manufacture of paper and related products. Tannin is available from some of the species of trees and is needed for the processing of hides, important to the leather industry centered mainly in Addis Ababa.

Until 1962, no commercial mining except for some gold had been developed within the Blue Nile River Basin. In late 1962, preparatory steps were being taken for mining limestone for a cement mill being constructed in the Addis Ababa Complex (at Akaki). In Eritrea there are deposits of the following minerals:

Sodium chloride
Sylvite) potassium salts
Carnallite)
Magnesium chloride
Sulphur
Iron ore (hematite)

Some can be brought within economical reach of Assab by completion of future highway programs.

Several large lakes within Ethiopia contain different varieties of fish, some of which are of very poor quality. The inland fishing industry is very poorly developed at present, but the sea fisheries are better, principally at Assab and Massawa. Some inland lakes and rivers do not contain large quantities of fish because of the high sodium content of the water. Commercial fishing in other fresh water lakes and rivers, such as Lake Tana, Lake Langano, Lake Awasa, Lake Abaya (Margharita), Lake Rudolph, the Awash River, and others, could contribute much to an enlargement of the food supply for the population as a whole. With this and the export market in mind, the second five-year plan proposes to start considerably extending fishing as a branch of the national economy. Studies will be made during this period to obtain as much information as possible regarding the quantity and species of fish in the coastal water near the Assab and Massawa areas. Also, similar studies will be conducted concerning lake waters along the Mojo-Awasa route.

Principal Economic Activities

Government planners hope to change Ethiopia from a predominantly subsistence agricultural economy to an up-to-date, efficient, agricultural-industrial one by the year 1982. To achieve this, it is hoped to maintain a rate of economic growth of about four or five percent per year on an average. The Gross National Product

and corresponding rate of growth are shown by Table VII-6 for the 20 years in the future. Over 12 billion Ethiopian dollars (total from government and private sources) will have to be invested over the next 20 years, as indicated by Table VII-7, according to the Office of the Planning Board, in order to achieve these goals. If this is the objective, it can only be achieved by a corresponding rapid acceleration in the construction of facilities to provide electrical energy to the principal industrial load centers. Perhaps 80 percent of this industrial development will occur in the Addis Ababa-Nazret area of the Addis Ababa Complex for several reasons.

Agriculture. Although there will be a substantial shift toward more industrialization within 20 years, agriculture has traditionally been the foundation of the Ethiopian economy, and the livelihood of perhaps 90 percent of the country's population is derived from basic farming activities or from the processing and exchange of farm produced crops and goods. Table VII-8 indicates the forecast trend in the export of certain agricultural products, which is an indication of a trend in anticipated future agricultural production.

TABLE VII-6 - GROSS DOMESTIC PRODUCT ESTIMATES OVER THE 20-YEAR PERIOD 1/

Periods	Gross domestic product (in million Eth$, 1961 prices)	Index number	Rate of growth
1958-1962	2,130	100	3.2
1963-1967	2,632	124	4.3
1968-1972	3,310	155	4.7
1973-1977	4,270	200	5.2
1978-1982	5,650	265	5.8

1/Second Five Year Development Plan.

175

TABLE VII-7 - ESTIMATED INVESTMENT DURING A 20-YEAR PERIOD 1/

Five year plan	Total investment (million Eth$)	Five year investment as percent of total	Index number (First Plan = 100)
Second	1,696	13.4	202
Third	2,420	19.1	288
Fourth	3,516	27.7	419
Fifth	5,050	39.8	601
Total	12,682	100.0	

1/Second Five Year Development Plan.

TABLE VII-8 - FORECAST TREND IN EXPORT OF CERTAIN AGRICULTURAL PRODUCTS 1/

Produce	In million Eth$, 1962 prices			Index (1962 = 100)
	1962 (Actual)	1967	1963-67	
Coffee	99.6	135.0	601.0	135
Hides and skins	22.7	28.7	125.0	126
Pulses	17.0	18.9	90.0	111
Oilseeds	14.9	21.2	96.0	142
Chat	10.2	11.0	54.0	107
Fruits and vegetables	4.7	6.2	27.0	131
Other	13.3	16.0	78.0	118
Total	182.4	237.0	1,071.0	

1/Second Five Year Development Plan.

176

Industry. Industrial activity in Ethiopia is confined primarily to processing agricultural commodities, producing foods and beverages, manufacturing some items for domestic consumption--tobacco products, footwear and leather products, and producing mineral products--cement, bricks, salt, and others. Drawings Nos. 4.0-BN-30, 4.0-BN-31, and 4.0-BN-32 show gross industrial production comparisons over a three- or four-year period.

Table VII-9 summarizes industry in the 13 provinces, exclusive of Eritrea, for the year ending September 10, 1961. A study of Table VII-10 will indicate that for the 11-year period, 1951 to 1961, inclusive, the volume of industrial production for all of Ethiopia, excluding Eritrea, increased over 4.5 times, and in the same period the production of electricity increased more than five times. During the period 1956 through 1961 (six years), the total manufacturing output of Eritrea increased by about 1.4 times, and that of the remaining 13 provinces more than 1.8 times during the same period. The total for the Empire of Ethiopia during the same period--that is, from 1956 through 1961--showed an increase in the output of manufacturing industries amounting to 1.7 times.

During the same six-year period, the output of electricity increased as follows:

Eritrea	1.6 times
Thirteen provinces	2.4 times
Total Ethiopia	2.2 times

During the period 1963-1967, the government planners foresee that the total output of the manufacturing industry would, on the whole, be tripled. Production of the more important industrial products is forecast in Table VII-11. Table VII-12 shows that before 1963, the investment in the forecast manufacturing industry was only about six percent. By 1967, this will have reached 19 or 20 percent annually and will probably hold to that figure for some time in the future. A tabulation of 103 new industrial projects to be completed and 18 more reconstructed during the period 1963-1967 is shown in Table VII-13. Of those to be completed, about 94 will actually go into operation within the same period as shown by Table VII-14.

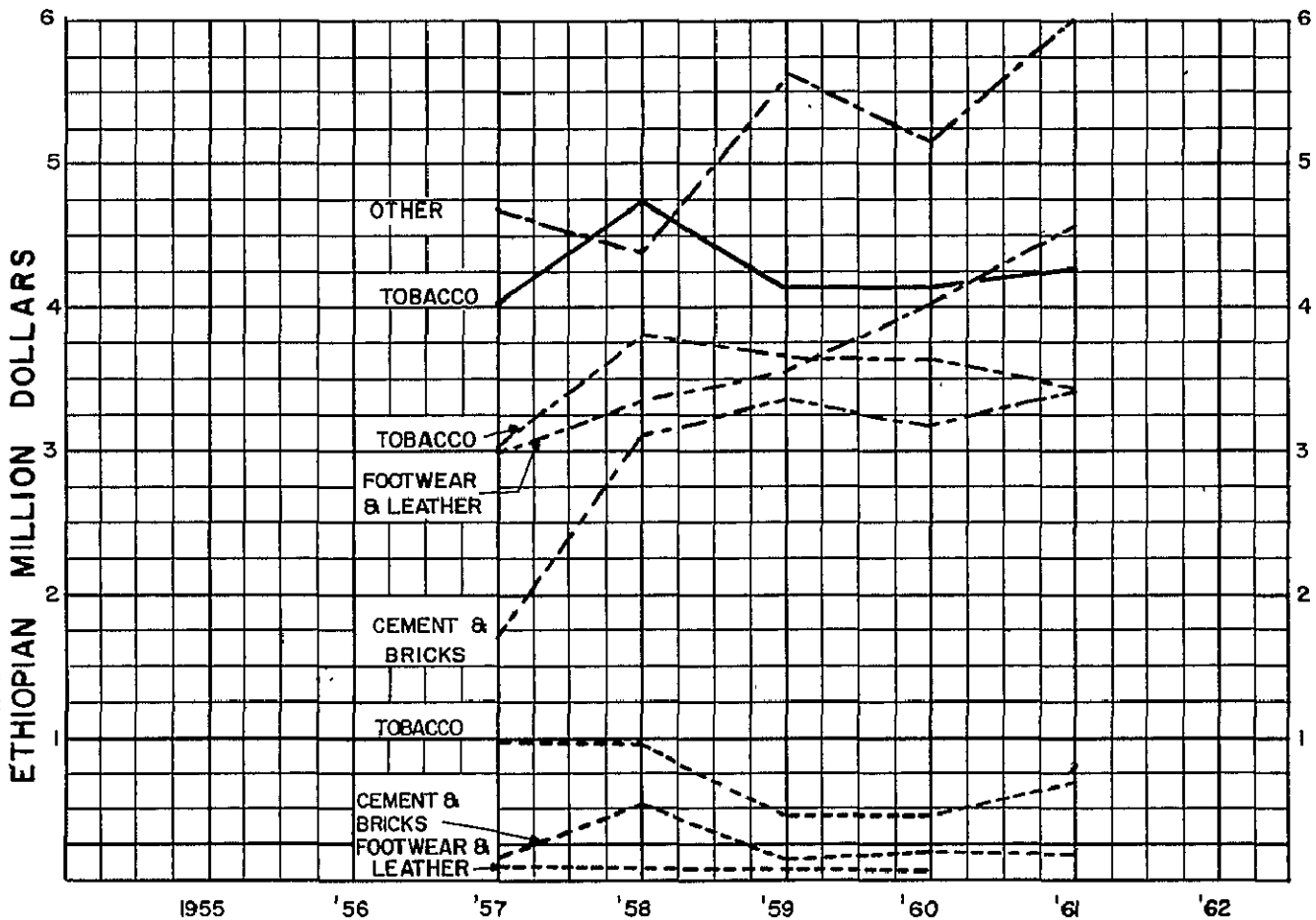
The emphasis being put on industrial development will require a corresponding increase in the availability of electricity supplies for supporting the increased industrial output. Some government planners foresee a 340 percent increase in the amount of electricity used for industrial purposes, using the year 1962 as a

TABLE VII-9 - SUMMARY OF INDUSTRY IN THE 13 PROVINCES (YEAR ENDED SEPT. 10, 1961)

Industrial Group	Number of establishments in operation		In thousands of Ethiopian dollars				
	1960	1961	Purchase of materials	Value of fixed assets 1/	Capital expenditure	Value of production Gross	Value of production Net
Food products	21	22	14,810	50,195	10,270	25,630	9,445
Flour, macaroni, biscuits	8	8	5,010	4,689	44	6,170	960
Edible oils and products	10	11	3,912	2,396	61	4,984	851
Sugar, tomato canning	2	2	5,882	41,610	10,065	13,816	7,017 2/
Slaughter and preparation of meats	-	-	6	1,500	100	660	617
Beverages	20	20	1,931	5,796	450	5,643	3,448
Alcohol, beer, liquors	6	6	549	3,036	235	3,062	2,362
Wines	7	7	1,023	1,003	33	1,569	489
Soft drinks and carbonated water	7	7	359	1,757	182	1,012	597
Tobacco manufactures	1	1	758	1,376	66	3,448	2,672
Textiles	8	9	18,569	15,868	2,934	32,722	13,053
Spinning, weaving, and finishing	3	4	16,400	14,095	2,825	28,232	10,941
Knitting mills, etc.	3	3	70	49	-	295	221
Cordage, sacks, rope, and twine	2	2	2,099	1,724	109	4,195	1,891
Leather tanning and footwear 3/	5	5	2,713	2,170	236	4,692	1,880
Sawmills, plywood, etc.	6	7	389	1,041	668	1,798	1,304
Furniture and fixtures 4/	3	3	1,012	485	52	1,660	633
Printing and publishing 5/	6	6	937	732	74	1,938	931
Chemicals and chemical products	-	-	192	715	165	606	392
Nonmetallic mineral products	3	3	304	1,880	84	3,477	2,906
Bricks	2	2	-	147	7	409	318
Cement	1	1	304	1,733	77	3,068	588
Miscellaneous manufactures	4	4	126	518	510	194	60
Total manufactures	77	80	41,741	80,776	15,509	81,808	36,724
Electricity	13	15	1,124	51,100	3,700	6,126	4,688
Total industry (excl. mining, construction, coffee and grain cleaning)	90	95	42,865	131,876	19,209	87,934	41,412

Source: Central Statistical Office.

1/Includes plant and machinery, vehicles, land, and buildings.
2/Excludes an estimated E$5 million of sugar cane grown on plantations of the industrial concern.
3/Excludes small shoemakers and shoe repairers.
4/Excludes small carpentry shops.
5/Excludes Berhanena Selam Printing Press in Addis Ababa.



FOR YEARS ENDING SEPTEMBER 10

---- Ethiopia's 13 Provinces
---- Eritrea
—— Empire, total, where shown

NOTES

1 Source : Ministry of Commerce and Industry

2 For total gross industrial production, see Drawing No.4.0-BN-32.

3 For gross industrial production selected industries see Drawing No.4.0-BN-31.

4 "OTHER" includes lumber, furniture, printing & chemicals.

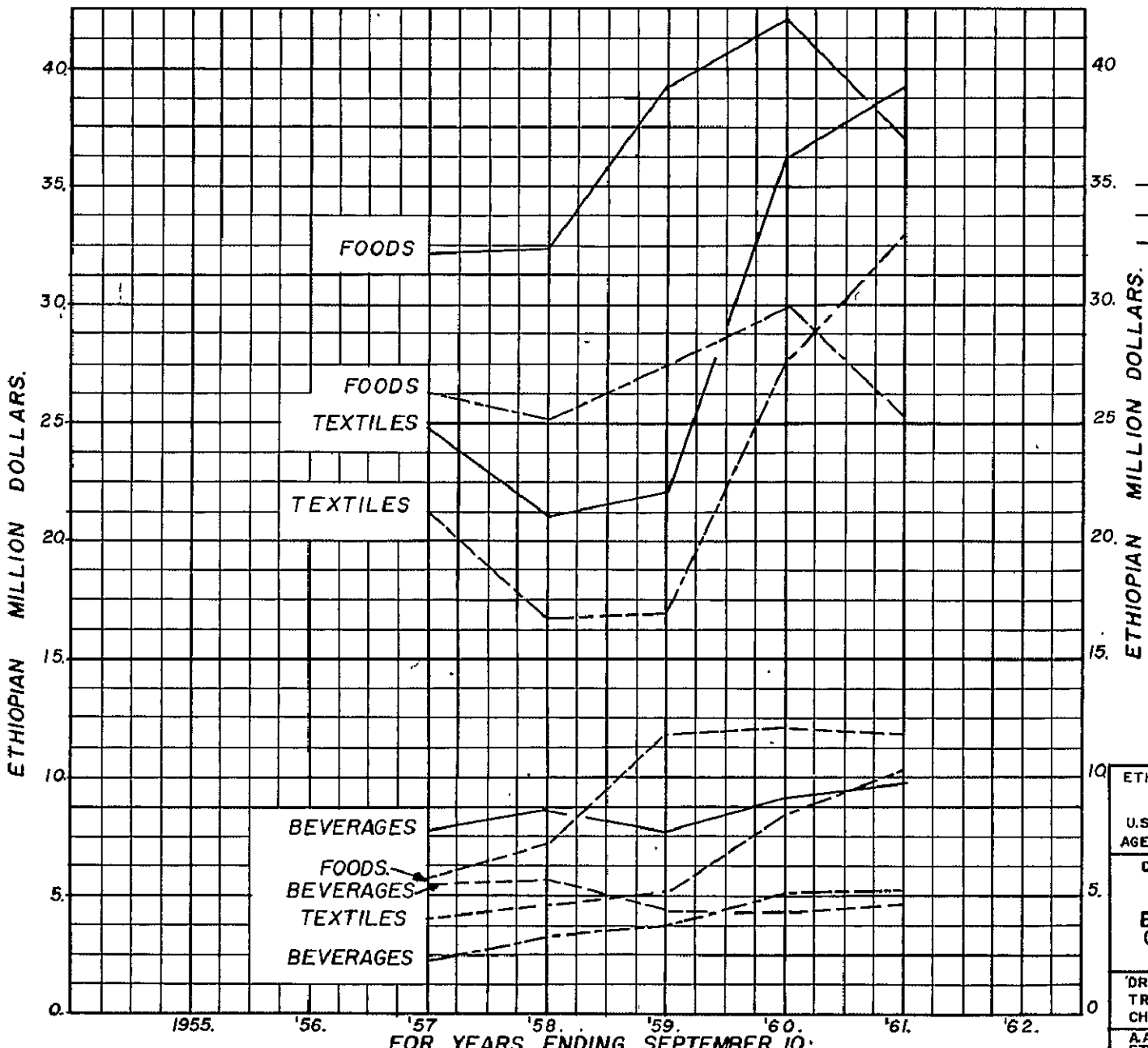
ETH-US COOP PROG. FOR THE STUD. OF W.R.
IN COLLABORATION WITH
U.S. DEPT OF ST INT. COOP ADMIN AND U S DEPT OF INT. BUR. OF RECL.
DEPT OF WATER RES IMP ETH GOVR.
MIN OF PUB WORKS & COMM
BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS
GROSS INDUSTRIAL PRODUCTION
SMALL INDUSTRIES

DRAWN C.L. Curtis SUBMITTED C.L.C.
TRACED Gebrechristos RECOMMENDED P.W.K.
CHECKED C.L.C. APPROVED C.E.B.

A.A May 21-1962 (I-C)
ETH. May 13-1954 (E.C)

4.0-BN-30



—— Ethiopia's 13 Provinces.
---- Eritrea
—— Empire, total.

Notes

1. Source: Ministry of Commerce & Industry.
2. For total gross industrial production, See Drawing No. 4.0-BN-32.
3. For gross industrial production, small industries, See Drawing No 4.0-BN-30.

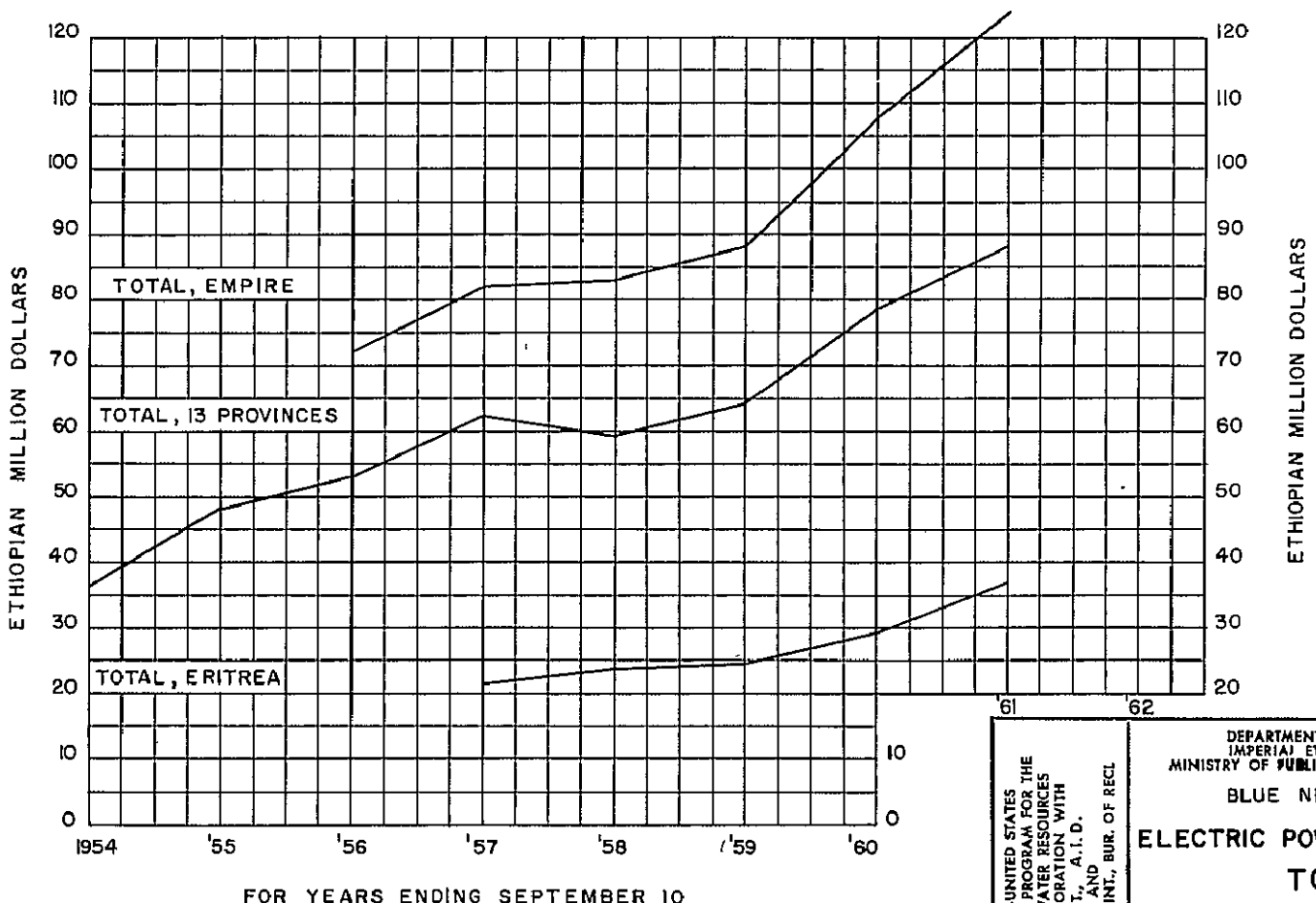
ETH U.S. COOP PROG' FOR THE STUD OF W R.
IN COLLABORATION WITH
U.S DEPT OF ST. AGENCY FOR INT. DEV AND U S. DEPT OF INT BUR OF RECL

DEPT. OF WATER RES. IMP. ETH GOVR.
MIN OF PUB WORKS & COMM

BLUE NILE RIVER BASIN
ELECTRIC POWER LOAD ANALYSIS
GROSS INDUSTRIAL PRODUCTION
MAJOR INDUSTRIES

DRAWN C.L. Curtis SUBMITTED C.L.C.
TRACED ASSEFA A. RECOMMENDED P.W.K.
CHECKED C.L.C. APPROVED C.E.B.

A.A. ETH | MAY 21, 62 (1.0) | 4.0—BN—31



NOTES

1. Excludes production of rock salt in Danakil plains, certain printing presses, and some coffee and grain cleaning industries
2. Source Ministry of Commerce & Industry & United Nations
3. For gross production of selected industries, see Drawings No. 4.0-BN-30 and 4.0-BN-31

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S DEPT. OF ST., A.I.D. AND U.S. DEPT. OF INT., BUR. OF RECL

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS
TOTAL
GROSS INDUSTRIAL PRODUCTION

DRAWN C.L. CURTIS . SUBMITTED G.L.C.
TRACED A.N. MUSSA ... RECOMMENDED P.W.K.
CHECKED C.L.C. . APPROVED C.E.B.

Addis Ababa Ethiopia | 21 MAY 1962 | 4.0-BN-32

TABLE VII-10 - INDEX OF ECONOMIC TREND OF INDUSTRIAL PRODUCTION (1955 = 100)

For the Empire of Ethiopia, 1956 through 1961																		
	The 13 Provinces						Eritrea Province 1/						Total, Ethiopia					
Industrial group	'56	'57	'58	'59	'60	'61	'56	'57	'58	'59	'60	'61	'56	'57	'58	'59	'60	'61
Manufacturing																		
Foods	109	128	132	146	162	158	84	69	92	77	132	89	103	113	122	129	155	141
Beverages and tobacco	114	114	122	154	179	216	108	112	117	107	103	106	113	114	121	142	160	189
Textiles	112	128	115	123	185	227	-	100	152	164	183	243	112	121	124	133	185	231
Leather goods	151	168	168	162	182	193)												
Building materials, etc.	117	91	115	93	100	128)	83	80	87	55	89	122	112	103	113	94	112	135
Miscellaneous	84	69	62	56	69	70)												
Total Manufacturing	112	124	124	134	165	183	92	102	124	110	145	141	107	119	124	128	160	173
Electricity (both public utility and industrial firms)	115	133	145	165	190	240	101	110	117	125	142	163	110	125	135	155	178	215
Total Mfg. and Elec.	112	123	123	134	163	181	93	103	122	111	142	139	107	118	123	128	158	171

For the 13 Provinces, 1951 through 1961 (1950 = 100) 2/											
Industrial group	'51	'52	'53	'54	'55	'56	'57	'58	'59	'60	'61
Manufacturing											
Foods	104	100	119	137	223	242	286	295	325	361	352
Beverages and tobacco	121	152	188	204	199	227	227	243	306	356	430
Textiles	72	197	267	313	395	444	507	452	485	731	895
Leather goods	113	191	197	206	213	322	357	358	346	388	411
Building materials, etc.	102	100	114	156	221	259	201	254	205	220	283
Miscellaneous	113	112	126	136	161	134	111	100	90	111	113
Total Manufacturing	101	133	163	187	249	280	308	308	333	410	455
Electricity (both public utility and industrial firms)	105	119	142	167	183	210	243	265	371	428	538
Total Mfg. and Elec.	101	130	161	184	235	263	288	290	314	382	425

Source: Central Statistical Office.

1/North Eritrea load center.
2/Primarily Addis Ababa complex.

TABLE VII-11 - 1967 PRODUCTION GOAL FOR SELECTED INDUSTRIAL PRODUCTS 1/

Article	Unit	Actual 1957	Actual 1962	Forecast 1967
Meat (frozen)	metric ton	683	5,500	35,000
Meat (canned)	metric ton	1,290	1,000	7,000
Sugar	metric ton	16,181	38,000	60,000
Salt	metric ton	132,292	158,000	275,000
Edible oil	metric ton	4,350	4,800	12,000
Flour	metric ton	23,000	24,000	51,000
Macaroni	metric ton	2,700	2,800	3,100
Beer	hectoliter	41,780	67,000	85,000
Wine	hectoliter	12,900	18,600	30,000
Cigarettes	1,000	252,000	370,000	500,000
Cotton fabrics	1,000 sq m	5,000	21,500	74,000
Rayon fabrics	1,000 sq m	--	--	6,000
Gunny bags	1,000	1,700	2,800	6,000
Shoes (leather)	pr	203,000	248,000	2,150,000
Shoes (canvas, rubber)	pr	--	--	1,300,000
Timber	cu m	16,300	12,500	20,000
Plywood	cu m	--	1,200	3,000
Furniture	Eth$ 1,000	350	450	1,300
Matches	1,000	11,800	16,000	25,000
Glass bottles	1,000	3,800	7,500	14,000
Cement	metric ton	26,860	29,000	210,000
Bricks	1,000	5,670	8,000	30,000
Mosaics	sq m	30,000	65,000	95,000

1/Second Five Year Development Plan.

183

TABLE VII-12 - INVESTMENT IN MANUFACTURING INDUSTRY BY YEARS[1]

Year	Investment (Eth$1,000)	As percent of total
Before 1963	25,560	6.0
1963	35,795	8.4
1964	57,445	13.5
1965	65,255	15.3
1966	74,795	17.6
1967	85,175	20.0
After 1967	81,925	19.2
Total	425,950	100.0

TABLE VII-13 - NUMBER OF INDUSTRIAL PROJECTS TO BE CONSTRUCTED--1963-1967[1]

Branch of Industry	Total	Breakdown	
		Completed or reconstructed	New projects
Food	29	3	26
Beverages	3	1	2
Tobacco manufacturing	2	1	1
Textiles	15	6	9
Leather and shoes	9	1	8
Wood	3	--	3
Building and nonmetal	16	3	13
Printing and publishing	2	1	1
Chemicals	22	1	21
Metals, production and fabrication, and electrical manufacturing	16	1	15
Other	4	--	4
Total	121	18	103

TABLE VII-14 - INDUSTRIAL PROJECTS TO BE PUT INTO OPERATION--1963-1967[1]

Year	Number of projects
1963	3
1964	19
1965	15
1966	24
1967	33
Total	94

1/Second Five Year Development Plan.

base. This increase would be for the period 1963-1967, inclusive. Until 1967 and perhaps a few years later, industrial production will primarily be geared to meeting consumer demands, although a start will be made in heavier industries, such as steel. A nucleus for the steel industry already exists, with the inauguration of a small Akaki steel mill in 1963, which depends primarily upon electricity for its energy requirements

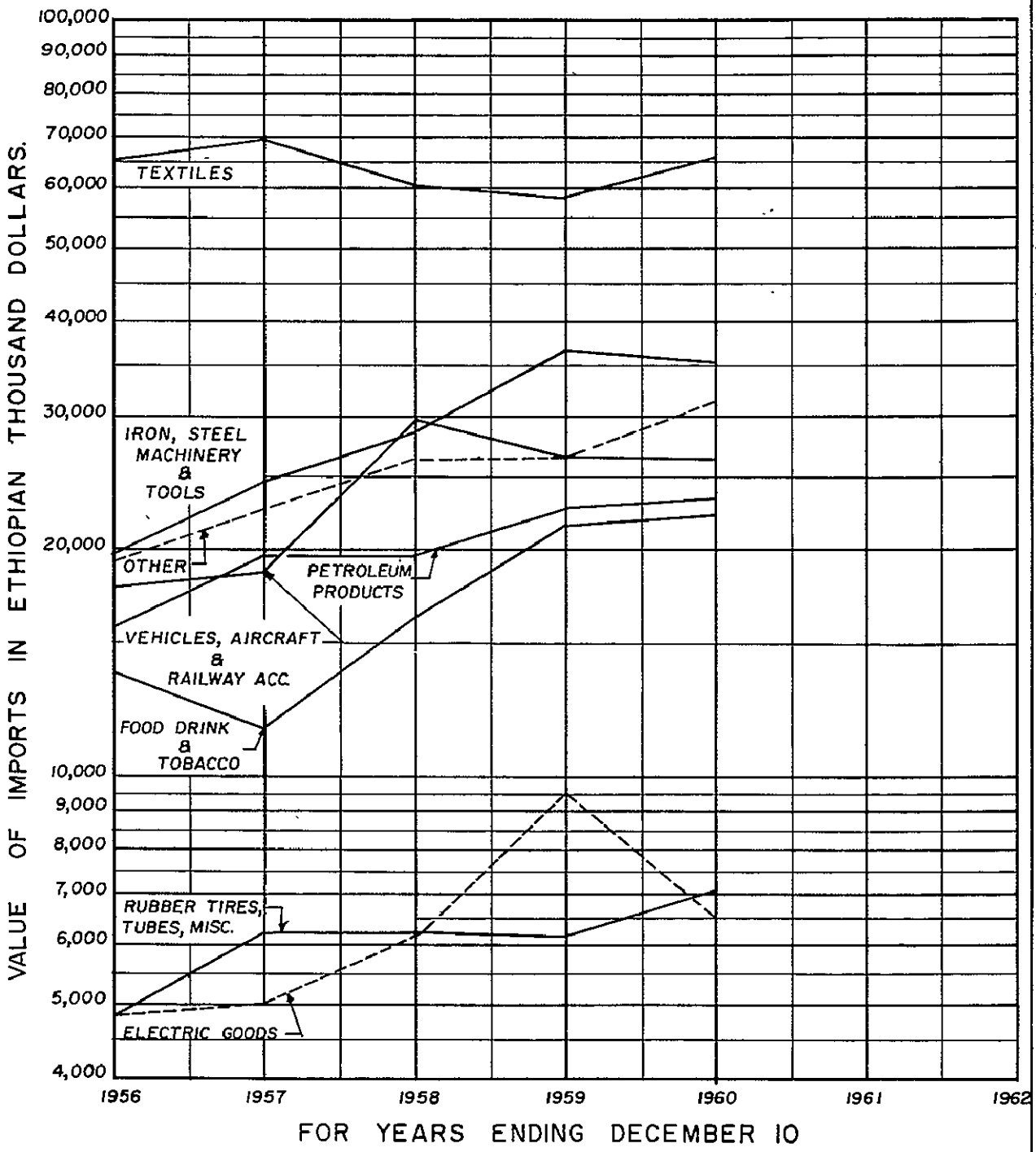
Trade. Ethiopia is primarily an importer of manufactured goods and an exporter of agricultural commodities. In value, cotton textiles represent the largest single import item, and coffee constitutes more than half of all exports. This is shown by Drawings Nos. 4.0-BN-33, -37, and -43. The second major import in value is manufactured items, such as iron, steel, machinery, and tools, which have shown a steadily increasing trend in recent years; this same increase is also reflected in the increased import of vehicles, aircraft, and railway accessories. To a lesser degree, certain food items, such as drink and tobacco, have also been imported at increasing levels for the past few years. Next to coffee, hides and skins assume second place in export value, although the value of exported pulses has recently shown a marked increase.

As shown by Drawing No. 4.0-BN-36, the value of imports has consistently exceeded the value of exports during the period 1959 through 1961, and it will also be seen that the value of exports has increased by 2.67 times and the value of imports more than three times during the decade 1950 to 1960.

The principal commercial cities in Ethiopia, in order of importance, are Addis Ababa, Asmara, and Dire Dawa. Dire Dawa is halfway between Addis Ababa and Djibouti, French Somaliland, and is the major town on the Addis Ababa-Djibouti railway. Addis Ababa is the focal point for both the distribution of imports and the collection of coffee, hides and skins, and other products for export. For this reason, all the principal firms engaged in foreign trade have their head offices in Addis Ababa.

The metric system is used in trade, but in local agricultural areas local units are used.

Government planners expect that foreign trade will constitute the third most important sector of the national economy, exceeded only by industrial and agricultural output. They recognize that, unless an accelerated sound foreign trade program is developed, the goals set for the agricultural and industrial expansion probably cannot be achieved. In the five-year period 1957 to 1962, inclusive,



Notes

1. *Source: Ministry of Commerce and Industry, Addis Aboba*
2. *For the 13 Provinces.*

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., AGENCY FOR INT. DEV. AND U.S. DEPT. OF INT., BUR. OF RECL

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

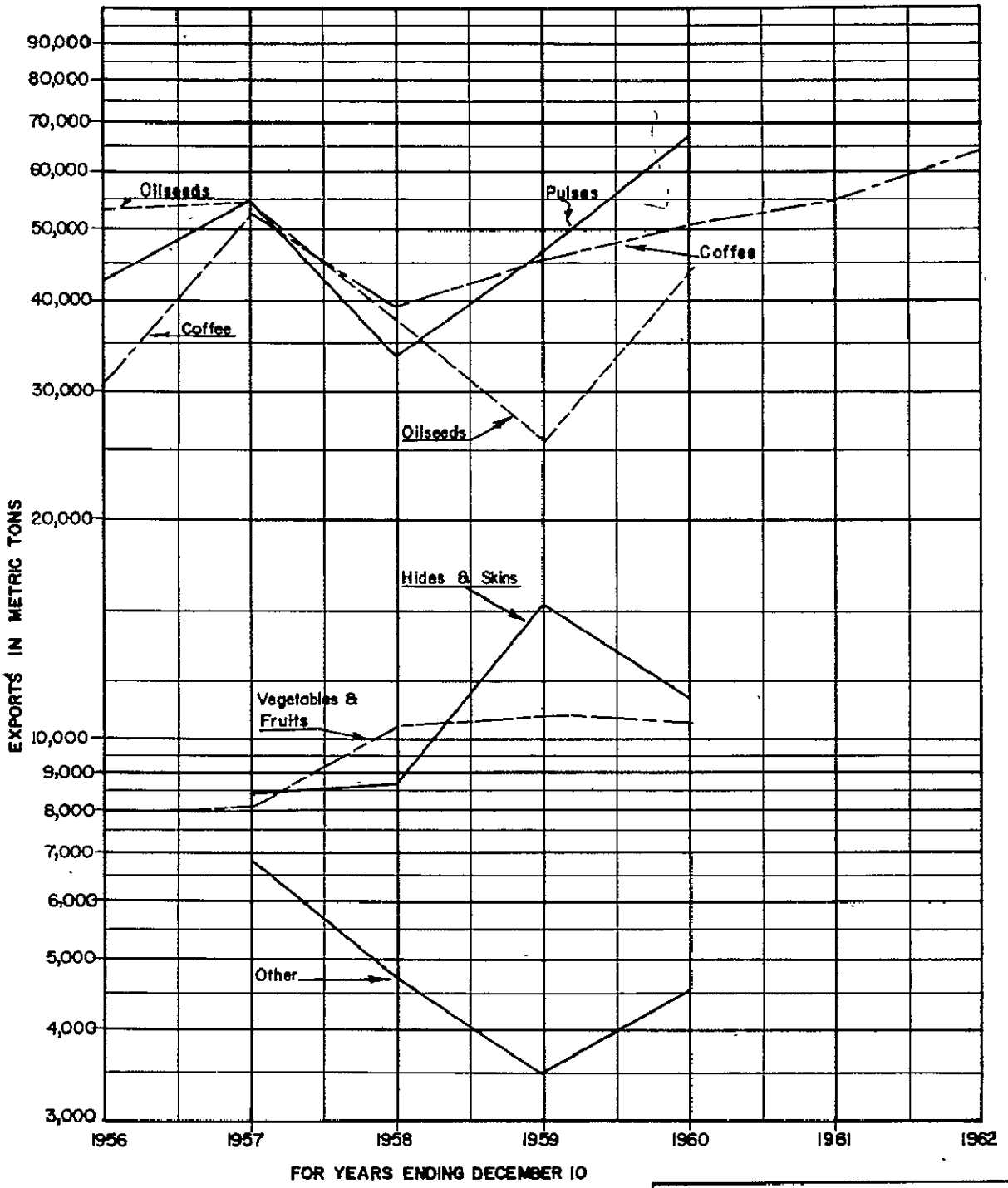
BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

MAJOR IMPORTS (DOLLAR VALUE)

DRAWN C.L. Curtis SUBMITTED C.L.C.
TRACED Assefa Ashagre RECOMMENDED P.W.K.
CHECKED C.L.C. - G.V.J. APPROVED C.E.B.

Addis Ababa Ethiopia | MAY 29 62(IC) | 4.0—BN—33



Notes

1. Source:

   Ministry of Commerce & Industry,
   Addis Ababa.

2. All major exports shown above are agricultural products and are for the 13 Provinces.

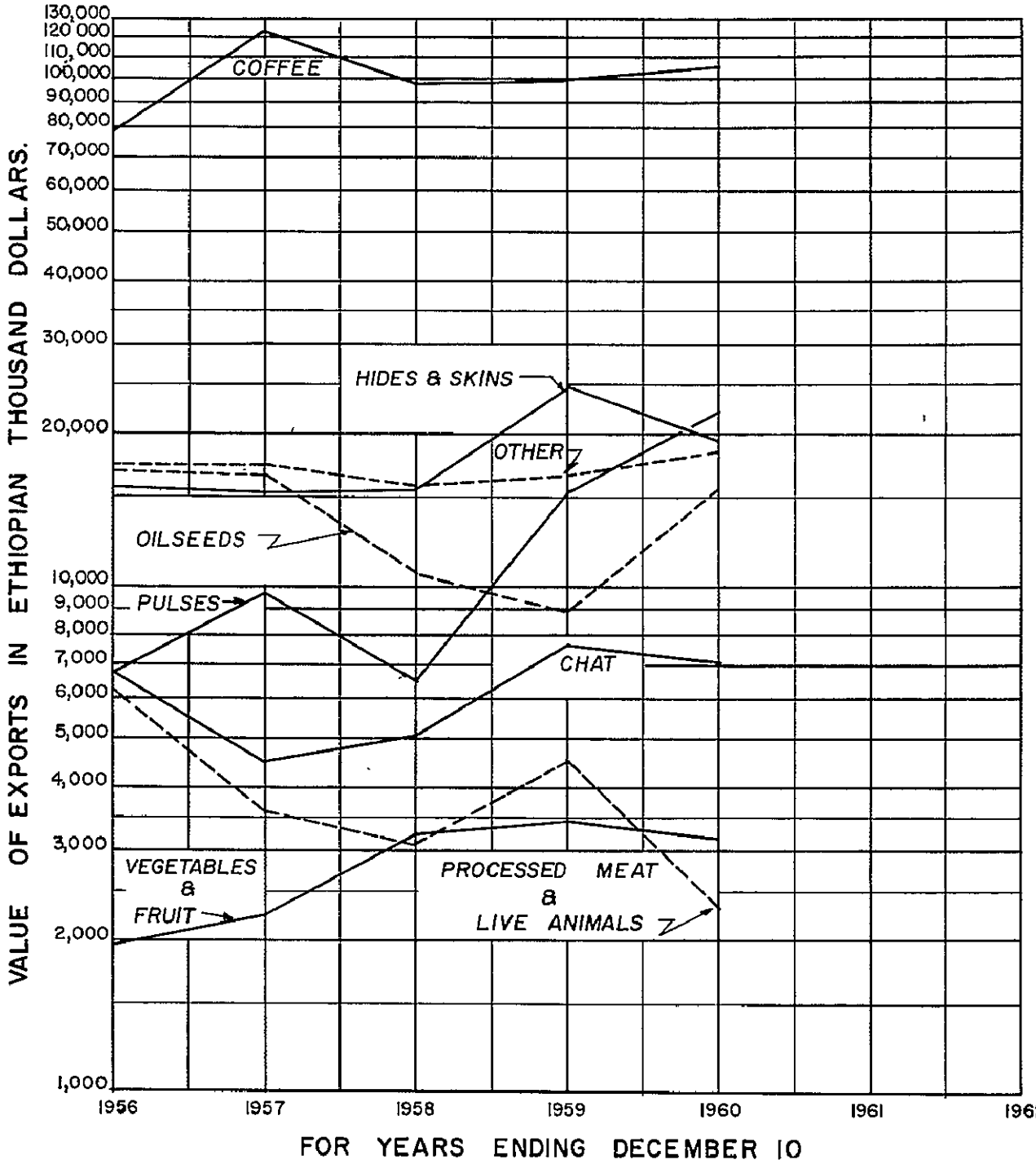
ETH. US COOP PROG. FOR THE STUD OF W.R.
IN COLLABORATION WITH
U.S. DEPT. OF ST AGENCY FOR INT DEV. AND U S DEPT. OF INT. BUR. OF RECL

DEPT. OF WATER RES. IMP. ETH. GOVR.
MIN OF PUB. WORKS & COMM.
BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS
MAJOR EXPORTS (Volume)

DRAWN. C.L. Curtis. SUBMITTED. G.L.C.
TRACED. Berhe N. RECOMMENDED. P.W.K.
CHECKED. C.L.C. APPROVED. G.E.B.

Addis Ababa Ethiopia | 15 May 1962 | 4·0 – BN-37



NOTES

1. Source:
   Ministry of Commerce & Industry, Addis Ababa.
2. For the 13 Provinces.
3. See Drawing No. 4.0—BN—39.

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U S DEPT OF ST, AGENCY FOR INT DEV AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

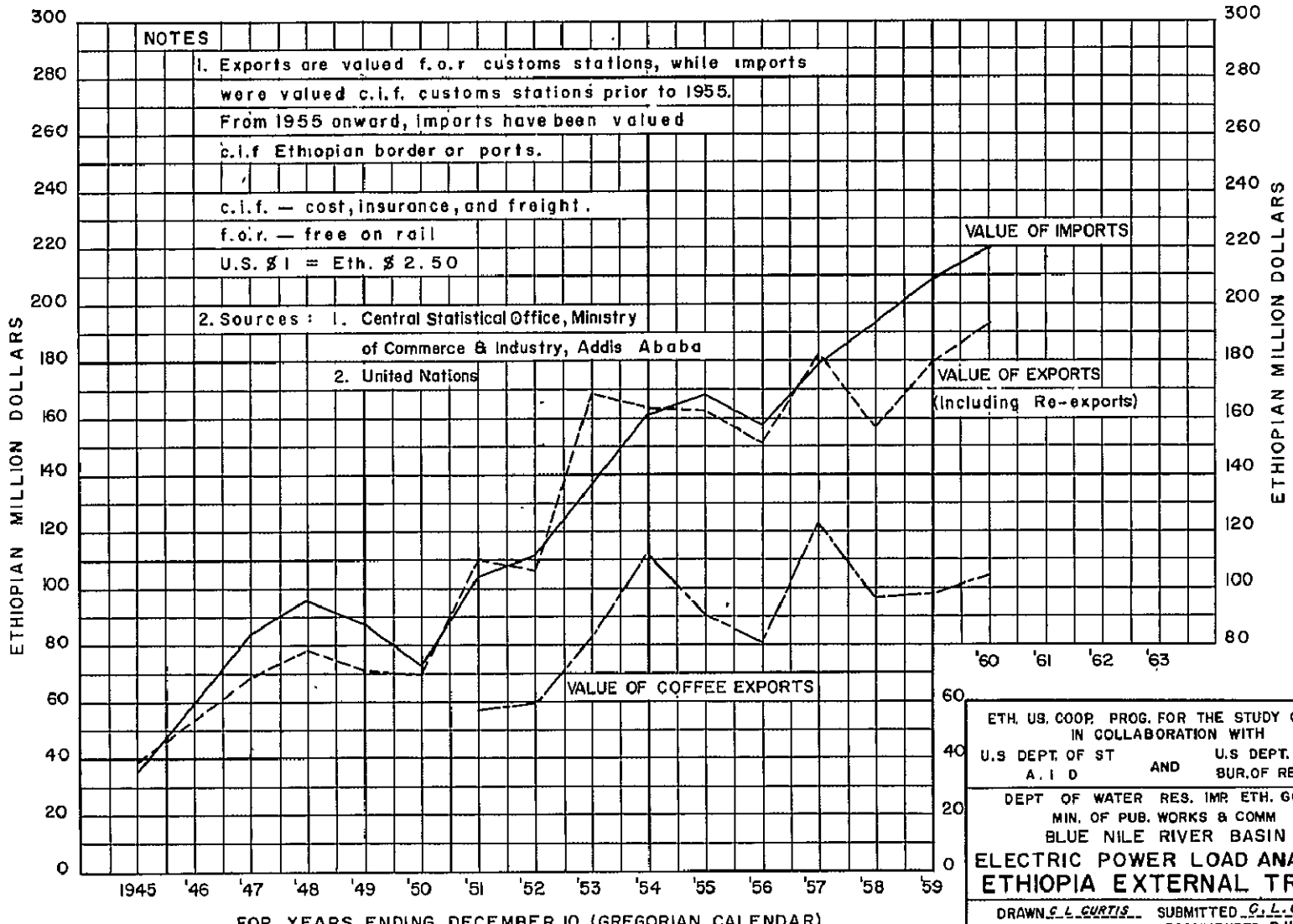
ELECTRIC POWER LOAD ANALYSIS

MAJOR EXPORTS (DOLLAR VALUE)

DRAWN C.L. Curtis . . . . SUBMITTED C. L. C.
TRACED Assefa Ashagre . RECOMMENDED P.W.K.
CHECKED C.L.C. . . . . APPROVED C.E.B. . . .

Addis Ababa Ethiopia | MAY 11, 62 (I C.) | 4.0—BN—43

188



ETH. US. COOP. PROG. FOR THE STUDY OF WR
IN COLLABORATION WITH
U.S DEPT. OF ST A.I.D AND U.S DEPT. OF INT. BUR. OF RECL.

DEPT OF WATER RES. IMP. ETH. GOVR.
MIN. OF PUB. WORKS & COMM
BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS
ETHIOPIA EXTERNAL TRADE

DRAWN C. L. CURTIS SUBMITTED C. L. C.
TRACED A. N. MUSSA RECOMMENDED P. W. K.
CHECKED C. L. C. APPROVED C. E. B.

A A ETH 16 MAY 1962 4.0-BN-36

the geographical distribution of foreign trade was rather uneven. Of the total Ethiopian imports in a one-year period (1959-1960), Western Europe supplied 43.1 percent; the United States, 15 percent; Japan, 13.1 percent; Eastern Europe, 7.0 percent; India, 6.0 percent; and all African countries, 2.3 percent. The export pattern for the same period showed 26.6 percent of exports going to Western Europe; 38.1 percent to the United States; Eastern Europe, 3.1 percent; Japan, 2.6 percent; all African countries, 6.9 percent; and India, 1.0 percent. Export forecasts for the period 1962 to 1967 are for an increase from Eth$194.9 million to Eth$327 million, or about 60 percent, an average annual rate of increase of 11 percent. Imports may grow faster, and these have been forecast at Eth$419.2 million for 1967 as compared with Eth$234.2 million in 1962, a total increase of 79 percent or an average annual increase of 12.3 percent for the period. Exports will rely principally upon traditional agricultural products, but it is expected that an important start will be made on the export of new industrial products as well as those from the mining industry. Table VII-15 shows the trend in anticipated exports by various basic economic sectors. From this table, it is evident that the largest increase will occur in the export of industrial products, followed by mining. Table VII-16 shows where, within the manufacturing industries, the expected increases in large exports will take place.

Mining. Mineral production has remained rather static in the past several years, but exploration and development investments have continued at an increasing rate with the largest investment being made in the Dallol potash reserves where an American firm is developing the salt deposits. Mineral production for the past few years has been limited primarily to gold, platinum, limestone for cement manufacture, sodium chloride (salt), quartz sand, and a little manganese ore. In the period 1963 to 1967, substantial quantities of iron ore and potash are scheduled for production. Both of these deposits are in eastern Ethiopia, the potash near Dallol and the iron ore deposits to the northeast near the seacoast village of Mersa Fatma. Table VII-17 shows the proposed increases by years in mineral production to 1967. Table VII-18 shows the gross value of mineral production in dollars anticipated as a result of mineral production estimates given in Table VII-17.

At present, most oil exploration activities are centered on the east coast of Ethiopia in the Eritrean coastal zone and adjacent islands. Another oil exploration area being actively investigated is in the Ogaden. A small amount of platinum mining activity is under way at Yubdo, with gold mining operations centered mainly in the Adola area.

TABLE VII-15 - FORECAST TREND IN EXPORTS BY SECTORS[1]
(IN MILLIONS OF ETHIOPIAN DOLLARS)

Sector	Actual		Forecast			Index percent 1962 = 100
	1962	Percent	1967	Percent	1963-1967	
Agriculture	182.4	93.6	237.0	72.3	1,071.0	129
Industry	10.2	5.2	80.0	24.2	185.5	784
Mining	2.0	1.0	10.0	3.0	38.1	500
Handicrafts	0.3	0.2	0.7	0.5	2.3	233
Total	194.9	100.0	327.7	100.0	1,296.9	

TABLE VII-16 - FORECAST TREND IN EXPORT OF INDUSTRIAL PRODUCTS[1]
(IN MILLIONS OF ETHIOPIAN DOLLARS)

Basic branches of manufacturing industry	Actual	Forecast	
	1962	1967	1963 -1967
Food	9.6	62.5	159.9
Leather and shoes	--	9.0	10.1
Building and nonmetal	0.1	3.2	4.1
Chemicals	--	3.3	4.4
Other	0.5	2.0	7.0
Total	10.2	80.0	185.5

1/Second Five Year Development Plan.

191

TABLE VII-17 - SCHEDULED MINERAL PRODUCTION, BY YEARS (1963-1967)1/

Mineral	Unit	1963	1964	1965	1966	1967
Gold, concentrate	kg.	800	1,000	1,200	1,200	1,200
Platinum, concentrate	kg.	10	15	15	15	15
Iron ore	metric ton	--	--	--	--	200,000
Manganese ore	metric ton	2,000	2,000	2,000	2,000	2,000
Potash	metric ton	--	150,000	300,000	300,000	300,000
Salt	metric ton	25,000	25,000	25,000	25,000	25,000
Quartz sand	metric ton	2,000	2,000	2,000	10,000	12,000
Clays	metric ton	--	--	--	--	5,000
Asbestos	metric ton	--	--	500	1,000	1,000

TABLE VII-18 - FORECAST GROSS VALUE OF MINERAL PRODUCTION1/

Year	Gross value (Eth$1,000)	Index number (1963 = 100)
1963	2,730	100
1964	7,435	272
1965	12,285	450
1966	12,740	465
1967	16,935	620

1/Second Five Year Development Plan.

The Imperial Ethiopian Government follows the basic policy of developing its mineral resources to the greatest extent its somewhat limited means permit, and at the same time to allow private persons and companies, both Ethiopian and foreign, to participate in exploration and exploitation. The Government also encourages the development of mineral resources to the greatest extent possible to obtain raw materials for the development of heavy industry, because considerable emphasis is being put on industrial development.

Since the greater part of Ethiopia, especially in the southwest, is largely unexplored insofar as mineral reconnaissance is concerned, the I.E.G. believes that the possibility of obtaining favorable results from a stepped-up investigations program is good, and this optimism is reflected in Tables VII-17 and VII-18.

Transportation and Communications. Two principal railroads are now in operation, the Addis Ababa-Djibouti Railroad and the Agordat-Massawa Railway. Both are diesel and diesel-electric operated. The Agordat-Massawa Railway is under the jurisdiction of the Ropeway Administration in Eritrea, while the Addis Ababa-Djibouti Railroad is operated by the Chemin de Fer Franco-Ethiopian, owned jointly by Ethiopia and France. The Massawa railway is 950-mm. track gage and is about 306 kilometers long, while the Djibouti railroad has 1,000-mm. track gage and is 781 kilometers in length. The latter handled about 44 percent of the total Ethiopian imports in 1959.1/ The Agordat-Massawa Railway serves the extreme northern portion of the country and Asmara, second largest city; the Addis Ababa-Djibouti Railroad serves the largest city, Addis Ababa, and the central portion of the country. The two are not connected. The total transport on both railroads in 1961 was 463,000 tons of freight and 700,000 passengers.

During the decade 1950-1960, more than 4,000 kilometers of automobile roads were opened to traffic, and traffic increased by more than 130 percent, with the number of registered motor vehicles increasing five times. The construction and maintenance of highways are of vital importance to any country, because adequate roads accelerate the economic development in the areas they serve. They are also important for national defense, and they will provide a means to consolidate the outlying regions in the Empire.

There are two main seaports with modern facilities--Assab and Massawa, both on the Red Sea and connected to the inland

1/Table 1(g) from Ethiopian Economic Review No. 2, June 1960.

area by good roads. Port traffic for a nine-year period at the port of Assab is shown by Table VII-19. A recently completed modernization program has improved port facilities.

Ethiopian Airlines, with head offices in Addis Ababa, provides internal air service throughout the Empire to some 20 or more airports. In addition, regular international services are provided to other places in Africa, Asia, and Europe.

Inland water transport is very small, being limited primarily to Lake Tana and to the Baro River. The latter, in the southwestern part of the country, has as its principal port the town of Gambela. From there, small boats sail down the river as far as its mouth on the White Nile near the town of Malakala in the Sudan and continue along the White Nile. Thus, part of the Ethiopian foreign trade is carried on with the Sudan over the Baro River. Small harbors and lighthouses for day and night traffic on Lake Tana have been built. For the future, opening of traffic associated with the development of fishing in Lake Abaya is a possibility.

At one time, posts, telegraph, and telephones were under the Post, Telegraph, and Telephones Ministry, but in 1952 the telecommunications were separated and established as a self-supporting public agency under the Imperial Board of Telecommunications. This organization provides the country with telephone, telegraph, and broadcasting facilities. Between 1955 and 1959, the urban telephone traffic in Addis Ababa increased 3.3 times. During the same period, the interurban traffic in the whole of Ethiopia increased about 1.7 times, the number of outgoing international calls about doubled, and incoming international calls nearly tripled. In 1953, the number of telephone instruments in Ethiopia was slightly over 4,500, but at the end of 1959 there were about 11,000 telephones in the country.[1] Radio broadcasting stations provide the primary link with the outside world. The major towns throughout the country have post offices and airmail service available where regular stops are made by Ethiopian Airlines.

City traffic in Addis Ababa has increased tremendously, as will be noted from the fact that in 1961, 49 buses had to transport some 12 million passengers while traveling 2.2 million vehicle-kilometers. Streets are being widened preparatory to the introduction of trolley bus transportation. City traffic increased four times during the period 1957-1961.

1/From Ethiopian Trade Journal, December 1960.

TABLE VII-19 - PORT ASSAB TRAFFIC--1952-1960

Year	Entry of ships		Passengers (number)		Goods Turnover (metric tons)	
	No.	Net registered tonnage	Disembarked	Boarded	Goods loaded	Goods unloaded
1952	205	173,259	443	428	57,842	17,241
1953	286	327,382	380	242	49,256	21,952
1954	412	426,972	498	361	106,372	46,059
1955	396	493,419	378	250	89,331	49,333
1956	405	505,562	388	334	82,680	53,510
1957	504	576,647	390	501	98,327	70,461
1958	605	973,944	409	327	90,106	69,237
1959	552	956,079	532	453	94,301	76,857
1960	487	871,690	625	534	84,000	91,000

195

During the period 1963-1967, further development of transport and communications is expected to average about 7.1 percent annually. The rate of growth of transport and communications will therefore be about twice as large as the rate of development of the whole economy, which has been estimated at an average of four or five percent annually.

Road construction will continue so that new regions can be opened for development. In addition to the rehabilitation and betterment of existing railways, large-scale studies concerning the possible construction of new railway lines will be undertaken. Table VII-20 indicates the planned amount of investment during the period 1963-1967 for various segments of the transport and communications. In addition to completing about 409 kilometers of roads under construction in 1962, about 800 kilometers of new main roads and about 1,000 kilometers of feeder roads are forecast. Studies and designs will be initiated to expand the existing railway network to include links from Nazret to Dilla, from Agordat to Tessenei, and from Awash to Tendaho to Assab. Additional post offices will be opened throughout the country, and the postal services will introduce their own means of transportation.

Tourism. In 1960, a little less than 4,000 tourists visited Ethiopia, but during 1962 it was estimated that tourists arrived on the average of from 100 to 150 per week. Tourists are beginning to realize that Ethiopia has more relics than any other African country except Egypt and that the tourist season lasts practically the year around, as there are varieties of climate in the country. Even so, modern tourism is at the initial stage of development. Such advantages as pleasant climate, natural scenery, mineral hot springs, historical monuments, and hunting all offer great possibilities for the development of planned tourism. It is planned during the 1962-1967 period to open a number of tourist information centers in several foreign countries and to restore some of the historical monuments that have deteriorated in recent years, as well as to provide facilities in selected locations in the Empire to attract the attention of foreign tourists. Hotel accommodations are being expanded in Addis Ababa and in some outlying cities, such as Bahir Dar. In the Blue Nile River Basin, many opportunities are available for attracting tourists, but at present tourist activity is limited primarily to the Bahir Dar area near the Tis Isat Falls and to the Blue Nile gorge on the Addis Ababa-Debre Markos highway. A vast reservoir of natural game and scenic attractions exists in the upper Dabus Swamp area which could be developed into a veritable tourist paradise. The Ethiopian Tourist Organization was very recently established to facilitate the handling of tourists and the promotion of the tourist industry.

TABLE VII-20 - PLANNED INVESTMENTS IN THE PERIOD 1963-1967[1]

Branches of transportation and communication	1963-1967 (planned) thousands of Eth$	As percent of total	Index number, ratio $\frac{1963-1967}{1958-1962}$
Transportation:			
Railways	10,000	3.2	143
Roads	155,600	49.2	122
Water	24,163	7.6	90
Air	89,153	28.2	187
Subtotal	284,916	90.1	131
Communication:			
Posts	5,000	1.6	--
Telecommunications	26,500	8.3	265
Subtotal	31,500	9.9	315
Total	316,416	100.0	139

1/Second Five Year Development Plan.

In summary, tourism is only beginning to be developed but offers a potential of being a major industry in the acquisition of badly needed foreign exchange. To provide for tourism, modern facilities will be required which will develop a gradually increasing demand for electric power and energy to serve these facilities. For example, hotels will be needed, and construction of these alone by various interests during the period 1963-1967 is estimated to require approximately Eth$19,000,000, with most of this capital invested in Addis Ababa.

Income

The per capita annual income was estimated to have been Eth$89 in 1955 but by 1961 the per capita income was about Eth$97. Income in the rural areas, where some 90 percent of the population live, is much lower than for the urbanized areas. The large population of Addis Ababa, where the income is higher than in outlying areas of the country as a whole, brings the per capita income average up for the country. Per capita income during the period 1955-1961 increased at a rate of about 1.12 percent per year for the country as a whole. A sample survey of rural areas conducted in four general agricultural sections of the country gave these per capita estimates of income for the year 1960-61.

Ambo-Guder	Eth$40
Sululta-Chancho	65
Lekkemt-Sire	50
Bure-Jiga	37

It was found that in the rural areas about 4.7 people per family were the average, while in the urban areas the number of people per family was 3.7--in only one specific sample area surveyed.

The upward trend of future per capita income probably will not greatly exceed the 1.12 percent experienced in the period 1955-1961. The upward trend in the real capita income probably will lie between one and two percent per annum. By the year 2000, the per capita income may reach Eth$175 per year. The Eth$175 figure will be based upon a two percent per annum increase in real income. The gross national product, however, may increase at a rate of around four or five percent during the greater part of this period.

Employment and wages and salaries paid by the manufacturing industry in Ethiopia during 1961 are shown in Table VII-21.

TABLE VII-21 - EMPLOYMENT TOTALS, MANUFACTURING INDUSTRY, ALL ETHIOPIA--1961[1]

Industrial group	Total number of employees[3]	Annual wages and salaries paid (Eth$)[2]	
		Total	Average per employee
Foods (meats, grains, sugar, canning, edible oils, and byproducts)	10,031	6,412,000	631
Beverages (alcohol, beer, liquor, wine, soft drinks, and carbonated water)	1,194	1,143,000	999
Tobacco manufactures	436	406,000	931
Textiles (spinning, weaving, finishing, knitting, sacks, cordage, rope, and twine)	9,675	5,757,000	595
Footwear and leather tanning	990	905,000	914
Sawmills, planing mills, and plywood	1,458	569,000	390
Furniture and fixtures	627	449,000	716
Printing and publishing (excl. Berhanena Selam Printing Press in Addis Ababa)	465	504,000	1,083
Chemicals and chemical products (incl. oxygen, carbon dioxide, matches)	514	135,000	263
Nonmetallic mineral products (brick and cement)	1,039	1,107,000	846
Miscellaneous manufactures	1,615	483,000	300

1/Based upon data from Statistical Office, Ministry of Commerce and Industry, Addis Ababa.
2/About 75 percent located in Addis Ababa Complex.
3/Includes 4,600 nonfactory sugar cane and tomato plantation workers and some 400 forest woodcutters, but excludes some 5,000 women handpickers employed in the coffee cleaning industry.

Development of Electric Energy Use

The long-term economic development of the country will result in a constant increase in electric power requirements and will thus also require a long-term planning program for the development of electric power to keep pace with needs. The Second Five Year Development Plan recommends that priority be given to further expansion of the hydroelectric system of the Awash and Blue Nile Rivers and further recommends the preparation of studies for possible interconnection of individual systems, creating a larger interconnected complex.

Two broad fields of use have been forecast in Ethiopia--use for the requirements of the national economy and use by the population and municipalities. The national economy requirements would presumably include (1) commerce and industry, including government enterprise; and (2) transport and communication as well as irrigation and municipal water. The public consumption and illumination of towns would include (1) farm, residential (urban), and government buildings; (2) public streets and highway lighting; and (3) other sales to public authorities.

Based upon a forecast in the Second Five Year Development Plan, total production of electricity would be divided as shown in Table VII-22.

TABLE VII-22 - USE OF ELECTRIC POWER PRODUCTION BY SEGMENTS

Segment	1962 (%)	1967 (%)
National economy	42.5	58.5
Public consumption and illumination of towns	40.0	23.0
Transmission and distribution losses, plus plant use	17.5	18.5

From Table VII-22 it is apparent that emphasis is and will continue to be upon improving the national economy segment and, within this segment, development of commerce and industry will require the bulk of the electrical power and energy produced. More specifically, the Second Five Year Development Plan (July 7, 1962 to July 6, 1967)

states that it is not possible to determine precisely the level of electric power production because production will depend upon completion of large industrial projects. However, the plan does define some instances where industrial development will occur.

During the period 1962-1967, government planners have scheduled an expenditure of Eth$353,400,000 for new industrial projects, while the remaining Eth$72,500,000 are to be used for completing projects under construction at the beginning of the 1962-1967 period and for the reconstruction of some existing factories. Out of 121 projects, 18 are being reconstructed or completed, and 103 new industrial projects are planned.

National Economy

No attemt is made in every instance to separate by individual load centers specifically the various commercial and industrial developments foreseen in the future as discussed in the ensuing paragraphs, although general consideration of these loads by location is made in the final load analysis presented in subsequent sections. Information as to specific locations for some of the proposed industrial plants was not obtainable, but it can generally be concluded that of those scheduled for the 13 provinces most of the load in this sector will fall within the Addis Ababa Complex.

Food Processing. Statistics are not available as to the amount of power and energy used in the food industry at the beginning of the Second Five Year Development Plan. Also, the specific capacity of every planned project was not always obtainable. However, it is known that 26 new food industrial processing projects are to be started and three existing plants reconstructed. The over-all rate of growth in this industry will be significant and will undoubtedly increase substantially with each successive five-year plan, as this industry will depend almost exclusively upon agriculture, which contributes 70 percent of the national income and employs 90 percent of the people.

Meat. The Second Five Year Development Plan forecasts the erection of several slaughterhouses in cattle raising regions and, after these establishments are placed in operation, the annual processing of more than 600,000 head of livestock. This would represent an increase of 600 percent in the production of processed meats by the end of 1967. The products of these new slaughterhouses will be frozen and canned meat intended primarily for export to foreign markets. To accomplish this, it will be necessary to fatten about 350,000 head of cattle and about 400,000 head of small livestock. This will be carried out by the large scale specialized farms which will be established during the period 1962-1967.

The total production of meat and meat products forecast in 1967, compared with 1957 and 1962, is as follows:

	Metric tons		
	1957	1962	1967
Meat (frozen)	683	5,500	35,000
Meat (canned)	1,290	1,000	7,000
Total	1,973	6,500	42,000

The source of livestock is no problem, because Ethiopia is classed among the countries of the world with the most numerous livestock in relation to the population. Disease control and measures for livestock improvement on a wide scale are planned by the Government.

To process 600,000 head of livestock per year (1967) would require about 18,000,000 kw.-hr. of energy with a maximum demand of about 6,000 kw., operated on a one eight-hour shift per day average. The power and energy requirement will, of course, depend upon the degree of electrification of the processing plants.

Although livestock is plentiful in certain areas of the Blue Nile River Basin, the bulk of the livestock is raised outside the basin, particularly to the south of Addis Ababa. Likely locations for processing plants are in Addis Ababa, Dire Dawa, Nazret, and Shashamane, all within the Addis Ababa Complex.

Dairy. Agriculture as a whole is expected to keep its pace of growth faster than the growth of population in order to supply adequate food for domestic consumption and more products for the processing industry and for export. One of those foods which is to be increased in quantity and quality is milk. Its main use will be to improve the diet of the population.

Provisions are made in the Second Five Year Development Plan for milk and dairy processing plants, but all locations were not obtainable. Plants totaling about 1,000 metric tons of annual capacity in Addis Ababa may possibly develop toward the end of the period. If this does, the annual energy requirement, 75,000 kw.-hr., would be very small, requiring a maximum demand of not more than about 50 kw.

Dairy products processing plants will develop more rapidly in the future, when the health conditions of cattle improve as a result of the control of livestock diseases and the improvement of quality through selective breeding.

Fruit and Vegetables. A small vegetable canning industry exists in Ethiopia, but vegetables are limited in the diet of people in many parts of Ethiopia. In order to improve the nutrition of the people, emphasis is being put on increasing the production of fruits and vegetables in the government's planning activities as evident in the Second Five Year Development Plan. For supplying the canning industry and larger towns, vegetable and fruit production is planned on a broader scale on large farms.

Present Ethiopian canned vegetable products are of good quality, and demand for them will undoubtedly increase in the future. During the next few years it is anticipated that at least one large fruit and vegetable canning plant may be established. A conservative annual energy requirement of 290,000 kw.-hr. with a maximum demand of 100 kw. is estimated by 1970, with increases after that date. This is based upon government planners' recommendations that during 1967 some 2,000 tons of quality fruit and vegetable products will be raised, largely on big farms.

The Ethiopian climate will permit growing certain varieties of fruit on a much greater scale than now. Very little of a fruit canning industry exists at this time. In a few locations, fruit is raised and sold in the larger towns. These fruits include citrus crops, bananas, grapes, papayas, peaches, and others.

Fish. The existing fishing industry is small and is generally limited to the Red Sea area, although fish are found in many of the inland lakes and could be developed into a thriving industry. With this in mind, the government planners have estimated that about 10,000 tons of fish products will be processed in the new plants to be erected on the Red Sea and on the lakes. In addition to supplying domestic needs, considerable quantities of fish products will be exported. Initially, the Red Sea fish processing plants will probably be established in Assab and Massawa. Each of these plants may require 250,000 kw.-hr. per year at about 80 kw. maximum demand. Initial production is estimated to begin during the period 1967-1970. Also, pending the results of studies of the inland lakes south of Mojo, it may be possible to erect a fish processing plant for drying and canning the better varieties of fish and processing the inferior varieties into fish meal and oil. This plant may require an investment of Eth$2,000,000, and for that size plant the initial energy requirement will be 250,000 kw.-hr. per year, with a maximum demand of 80 kw., and substantial increases are possible later.

Sugar. Sugar production in prior years, compared with the government planning goal in 1967, is as follows.

	Metric tons		
	1957	1962	1967
Sugar	16,181	38,000	60,000

In 1967, 60,000 tons of sugar cane will be produced. Sugar production in the past has not depended to any extent upon external electrical energy sources because processing plants have generally supplied their own energy. This was due partially to the lack of external electrical power sources. Also, the inherent nature of sugar processing requires steam, and a portion of this was utilized for conversion to electrical energy where required. However, government planners anticipate that during the period 1967 to 1972 a large sugar factory will be erected, the size of which has not been precisely determined. There is some indication that it might be capable of producing 30,000 tons of sugar per year, and on this basis the total annual energy requirement would be about 14,600,000 kw.-hr. with a maximum demand of about 4,000 kw. indicated. Part or all of this energy may be supplied from external sources. Sugar production will steadily increase in the future.

Confectionery. Practically all confectionery items are imported, but a small chocolate and candy factory is under way and others will undoubtedly follow because the major ingredients, sugar and oils (shortening), are available in Ethiopia. It is estimated that the first plant in Addis Ababa will require 135,000 kw.-hr per year, having a maximum demand of 47 kw. This is but a modest beginning, and this industry will expand considerably in the future.

Oil Pressing and Margarine. The production of edible oils in Ethiopia during 1957 and 1962, as compared with the planning goal in 1967, is shown below.

	Metric tons		
	1957	1962	1967
Edible oil	4,350	4,800	12,000

The production of oil seeds will increase from 351,000 metric tons in 1961 to 424,000 metric tons in 1967, or an increase of 73,000 metric tons (20 percent). However, of the 73,000 tons, 40,000 will be used by existing and planned industries, including cottage and handicraft industries, by 1967. Conversion to edible oil will be in the amounts indicated above, which will require additional oil seed pressing mills. Construction of additional pressing mills is planned. Before 1970, it is likely that a 6,000-ton per year mill

204

to supply processed oil for a margarine plant, the first in Ethiopia, will be established in Addis Ababa. The annual energy requirement for such a mill will be quite small, something on the order of 290,000 kw.-hr. per year with a maximum demand of about 100 kw. This would be merely the forerunner of similar plants that may be established in the future with substantial energy requirements foreseen.

Beverages. This category includes the production of wines, liquors, alcohol, soft drinks, and tej, the latter a local, popular wine using honey as a base. Production, past and future, of principal beverage items is as follows.

	Hectoliters		
	1957	1962	1967
Beer	41,780	67,000	100,000
Wine	12,900	18,600	85,000-100,000

The government planners foresee an increased production in 1967 of 85,000 to 100,000 hectoliters of wine. Substantial increases in soft drinks, alcohol, and tej are also forecast. One new brewery will be established by 1967 to provide for the increase in beer production. Also, there is some indication that a small whiskey distillery may develop during this period. While annual energy and power requirements will initially be very small, these industries form the nucleus for the start of a promising industry in Ethiopia with substantial power requirements in the future.

Initially, the small distillery would not use much more than 60,000 kw.-hr. per year at a maximum demand of 20 kw. To increase the production of beer in the amount indicated by government planners, modern brewing principles would call for an annual energy requirement of 3,285,000 kw.-hr. with a maximum demand of 400 kw.

Miscellaneous. The production of certain other food items is to be stimulated, according to government planners, and this applies particularly to such items as flour, powdered coffee, macaroni, and eggs. Ethiopia had been an exporter of wheat until quite recently, when it began to import small quantities of wheat to provide for the needs of the increasing population. In 1957 and 1962, flour and macaroni were processed in the amounts shown below.

	Metric tons	
	1957	1962
Flour	23,000	24,000
Macaroni	2,700	2,800

For 1967, the goal is 51,000 tons of flour and 3,100 tons of macaroni, representing increases of over 100 percent for flour and about 10 percent for macaroni. Flour milling will require additional power and energy, with requirements for 1967 amounting to 3,100,000 kw.-hr. with a maximum demand of 700 kw. Some six flour mills are planned.

A new factory for the production of powdered coffee is to be constructed during the 1962-1967 period, to have an annual capacity of 3,000 tons; in the year 1967 it will produce 1,500 tons of powdered coffee for export.

Textiles and Wearing Apparel. The per capita consumption of cotton textiles in 1961 was estimated at 2.3 square meters, with the estimated consumption to reach 4.3 square meters (88-percent increase) by 1967. The consumption of cotton in 1967 will be 24,000 tons, according to government planners. In different terminology, the gross value of the total textile industry production in 1961 was Eth$39,000,000, and the gross value in 1967 is forecast at Eth$88,860,000, or an increase of 128 percent. The bulk of the textile industry production will therefore be in cotton textiles. The estimated production of cotton fabrics will increase from 21.5 million square meters in 1962 to 74 million square meters in 1967. A new rayon factory of 1,500-ton capacity is to be completed in 1964. The increased production of cotton and synthetic fabrics is intended to satisfy the domestic needs. Cottage industries will increase and will require cotton yarn, the production of which will be increased. Along with this, the manufacture of such final goods in the textile industry as blankets, hosiery, and knitted wear is also being planned.

A new woolen products factory is planned that will produce about 270,000 blankets a year in addition to other goods, thus reducing the need to import these items. Using basic domestic raw materials, primarily flax, another factory will be constructed to produce 500 tons of flax products (linen and oil) yearly. The erection of a factory to produce 100,000 umbrellas yearly will also be accomplished by the end of 1966. A factory for processing musa (a fiber plant) with an annual capacity of 1,000 tons is to be built by the same target date. The output from this factory will be added to other sources to increase production of sacks and rope from 2.8 to 6.0 million pieces, in part from another new factory having an annual capacity of 2,000 tons. The erection of a ready-to-wear clothes factory is also planned, which will supply the immediate needs of military and civilian demands.

In summary, there will be nine new textile factories developed by the end of 1967 with six existing ones completed or

reconstructed. This trend may continue in the future in order to provide the basic needs of the expanding population, and the requirement for electricity will thus increase greatly.

Existing leather and shoe factories, with tariff protection from external imports, will be able to produce about 1,000 tons of leather and 650,000 pairs of leather shoes in 1967. The erection of the new slaughterhouses will make available an increased quantity of hides and hence considerably increase the production of leather and shoes. Government planners expect to establish several new leather and shoe factories with a total capacity of 8,000 tons of leather and five million pairs of shoes to be produced. Production will exceed national demand, so export is contemplated. To meet the demand of the domestic market for low-priced footwear, the erection of a canvas and rubber shoe factory has been planned with a production of about 1,300,000 pairs in 1967. All told, one leather and shoe factory will be completed and eight new ones started by the end of 1967. By that year, 2,150,000 pairs of leather shoes will be produced annually.

Forestry Products. In 1962 about 12,500 cubic meters of lumber were produced from domestic timber, and this is expected to rise to 20,000 cubic meters by 1967. A new sawmill will be constructed, but it will not in all probability be driven by electric motors. In 1962, about 1,200 cubic meters of plywood were manufactured, and by the end of 1967, this is expected to increase to 3,000 cubic meters.

Increased production of furniture and other final wood products will occur as a result of the construction of a new furniture factory which is planned by 1965. Three new, wood products industrial projects are to be established by 1970, including the sawmill and furniture factory already noted, plus a new, 10,000-ton annual capacity mill.

There are good prospects for a substantial increase in production from this industry in the future as special emphasis will be placed upon afforestation and preservation of existing forests. During the period 1962-1967, feasibility studies using some existing forest products for paper pulp, tannin, and resin will be completed and, if prospects are favorable, industrial projects will be started.

Factories which are needed and will probably eventually be constructed include, in addition to those cited, plants specializing in the manufacture of cardboard boxes and paper containers and of prefabricated buildings.

The electrical power load requirements in this field alone will be significant as industrialization progresses, and these loads are included in the totals shown in subsequent charts and graphs.

Chemicals and Related Items. A chemical industry, as such, barely existed in Ethiopia as late as 1961. However, the discovery of some basic minerals and the domestic demand for chemicals now imported, have led government planners to forecast a very intensive development of the chemical industry, beginning with the period 1962-1967 and continuing into the future. The new capacities of this industry are to be based mainly upon domestic raw materials for the production of pulp for paper and viscose, caustic soda, sulphuric acid, carbon bisulfide, pharmaceutical products, soap, glass, leather tanning material, and others.

As Ethiopia is badly in need of a nucleus for a chemical industry, a logical site for early establishment of plants to provide the basis for the industry may be in the vicinity of Assab. (The only large oil refinery in Ethiopia will be located there.) Whether this will be the location finally selected is impossible to forecast; however, the availability of salt (sodium chloride) in abundance and the availability of sylvite and carnallite (potassium salts) as well as other salts in the Danakil area (vicinity of Dallol) will provide some of the raw materials. Production will be initiated at the rate of 300,000 tons per annum. This includes the building of a new, deep water port and a new, 97-kilometer (58-mile) road.

About 200,000 metric tons of salt are produced annually from sea water, and most of this is exported. About 20,000 tons of rock salt are also produced for the local markets.

Table VII-23 indicates the chemical plants which could be developed at Assab, assuming adequate electrical power at reasonable rates becomes available. (Assab may be the logical site because of a good road to the interior of Ethiopia and the proposed location of an oil refinery there. Adequate supplies of nonsaline water are questionable, however.)

TABLE VII-23 - CHEMICAL PLANTS POSSIBLE OF DEVELOPMENT NEAR ASSAB

Plant	Maximum demand (kw.)	Annual Energy requirement (kw.-hr.)
Caustic soda; and Salt electrolysis and chlorine	3,770	33,000,000
Sulphur extraction	60	470,000
Potassium fertilizer	195	800,000
Nitric acid and fertilizer	40	350,000

Large quantities of salt (NaCl) are available as rock salt in the Danakil area or from sea water by evaporation. Electrolysis of NaCl will produce caustic soda (NaOH), an essential basic chemical for a diversified industry. Chlorine and hydrogen are also released in this process. Chlorine can be liquified and transported. Hydrogen gas can be used to produce ammonia and hydrochloric acid, both essential industrial chemicals.

Fused salts at high temperatures, free from water, can also be decomposed. Fused salt is electrolyzed to produce metallic sodium at a very low cost to be used in the preparation of a number of other chemicals which could not otherwise be processed, including sodium peroxide and sodamide, essential for any chemical industry. A host of important derivatives of metallic sodium can be developed, only one of which is described here.

Sodamide is made by the action of dry ammonia on metallic sodium. It is used for the synthesis of indigo and in other organic reactions. When heated with carbon, sodamide is changed to sodium cyanide, in great demand for electroplating, in fumigation, in the extraction of gold, silver, zinc, and lead from ores, and in a mixture with sodium chloride and sodium carbonate for case-hardening of steel.

The direct synthetic ammonia process passes pure nitrogen and hydrogen over a catalyst under pressure and at high temperature. By catalytic oxidation, ammonia is easily changed into nitric acid and this in turn into nitrates (fertilizers).

Crude carnallite, such as is available around Dallol, can be refined to potassium chloride by treating the crushed ore with a hot solution of magnesium chloride. Two grades of potassium chloride (KCL), one for higher grade chemical uses and one for fertilizer, can be produced. Some sylvite is also available, as is potassium chloride (KCL) in a crude, natural state. These have important uses in making liquid and soft soaps, in photography and medicine, in explosives, and in glass making.

Chemically pure hydrochloric acid can be produced by burning electrolytically produced chlorine in excess hydrogen.

Magnesium chloride is available in a natural state 18 kilometers southwest of Dallol. Magnesium can be made by the electrolysis of fused anhydrous magnesium chloride in an electrolitic cell containing potassium chloride.

In the Dallol area, sulphur minerals have been found from which sulphur can be extracted. Its most important use is in the manufacture of sulphuric acid, essential to any chemical industry. It is also necessary for possible future industries, such as the manufacture of paper, matches, gunpowder, insecticides, fertilizers, and vulcanizing (rubber industry).

Thus, the five plants that have been described are all closely related and require only modest amounts of electricity, except for those using the electrolysis processes. The processes described are not all covered by the five plants listed, so other plants could be added when justified. If all processes mentioned were to be developed, the electrical energy requirement would easily triple, with the ultimate requirement depending upon the demand for the products.

In 1962 the gross value of production of the chemical industry was estimated at Eth$950,000 as contrasted with a forecast production in 1967 of Eth$36,100,000, or an increase of 38 times. To indicate the degree of emphasis being placed upon this industry, it was noted that government planners forecast a total investment of Eth$51,050,000 in this segment during the period 1963-1967 as compared with Eth$740,000 for the previous five-year period, or an increase of 690-fold.

According to government planners, the chemical industry will expand by 21 new plants during the period 1963-1967 (Table VII-13). Early emphasis seems to be directed toward supporting synthetic fiber plants and pulp mills with the necessary raw materials. Production of wood pulp will be initiated to support a new 8,500-ton capacity paper factory and a 12,000-ton viscose

210

factory. These factories will need chemicals, and to supply their needs a caustic soda factory (12,000 tons), a carbon bisulfide factory (6,000 tons), and a sulphuric acid factory (20,000 tons) will be required. Availability of domestic raw materials will justify the erection of a 6,000-ton soap factory. Two tanning material factories will be established, having a total annual output of 2,000 tons. Source of raw material is domestic trees, and the output from the factories will be used primarily in the domestic leather industry. Deposits of quartz sands will be used to increase the output of existing glass factories as well as a basis for erecting a new glass factory with an annual output of one million square meters. (In 1957 the output of glass bottles was 3,800,000; in 1962, 7,500,000; and in 1967, the forecast is 14,000,000 bottles, an increase of 1.87 times.)

All pharmaceutical products are imported, but during the period 1962-1967, government planners expect that a pharmaceutical factory will be constructed. In addition, a plastic product factory and a tire plant are to be constructed. Near 1966, a start will be made on one of these factories: fertilizer plant, paint plant, pharmaceutical plant No. 2, soap factory No. 2, lubricating oil plant (expansion of the then existing refinery), or PVC plant (polyvinyl chlorides).

By 1967 or shortly thereafter, the industrial power requirements will be significant and will be supplied primarily from hydroelectric sources. Some industrial plants, such as the sugar factories, may not initially depend upon electricity from an external source, but at present the most economical source of energy in Ethiopia is hydroelectric power and it probably will remain so in the future.

Although complete proposed production information for every factory is unknown at this time, an estimate of future power and energy requirements is included in the totals shown in subsequent charts and graphs.

Petroleum. There was no oil produced in Ethiopia in 1962, but oil exploration continued on the Red Sea coast, including the islands, with some favorable results obtained which would warrant a drilling program. In the eastern area of Ogaden, exploration by the Gewerkschaft Elwerath Oil Company continued with the results unknown in 1962. Construction planning has started on an oil refinery at Assab with a capacity to handle about 500,000 tons yearly. This will be increased (doubled) if domestic crude oil is discovered, and the addition of a lubricating oil plant is planned later.

The power requirements of the Assab refinery will be substantial, with a 2,000-kw. load and an annual requirement of more than 11,650,000 kw.-hr. Maximum development may require 5,000 kw. and 40,000,000 kw.-hr. annually.

Establishing the refinery at Assab would favor the location there of the chemical plants previously described.

Mineral Products

Mining. All mineral rights in the country are under the control of the Imperial Ethiopian Government, which operates two gold mines and a platinum mine. Concessions are granted by the Government on a profit-sharing basis, and perhaps two of the more important concessions granted in recent years are those to the Ralph M. Parsons Company and the Gewerkschaft Elwerath Oil Company (see "Petroleum"). The Ralph M. Parsons Company, a U.S. firm, has a concession to mine potash at Dallol, 95 kilometers (56 miles) south of the Red Sea port of Mersa Fatma. The concession was amended to include other minerals. Ore bodies of sylvite, carnallite, and other salts have been discovered, and production will be at the rate of 300,000 tons per annum.

The Societa Saline di Massaua and the Societe des Salines d'Assab each produce about 100,000 metric tons of salt annually from sea water.

A small amount of manganese ore is exported from a deposit at Enkefella, 18 kilometers southwest of Dallol.

If a proposed barter arrangement with Krupp Industries, West Germany, is consummated, 300,000 tons of 60-percent iron ore (hematite and magnetite) will be exported annually from Agometta, 30 kilometers southwest of Massawa.

Many other minerals have been found in Ethiopia, but most have not been in sufficient quantity to justify much commercial exploitation. These include copper, lead, mica, vermiculites, gypsum, alabaster, pumice, magnetite, phosphates, talc, graphite, and precious stones.

Predictions are that future electric power requirements in the mining industry will remain low but should show some increase by 1966. A small hydroelectric plant has been constructed by the IEG to serve one mining area, and until the interconnected transmission system is extended from its present location, this will be the pattern followed to meet future mining loads.

Cement and Cement Products. The Ethiopian Cement Corporation, a state-owned firm, quarries clay and Jurassic limestone at Dire Dawa to product portland cement. Production in 1959-1961 has been from 25,000 to 30,000 tons. A new cement factory was started in 1962 in Addis Ababa, capable of producing 70,000 metric tons of cement per year from limestone deposits discovered by U.S. Bureau of Reclamation geologists in the Muger canyon about 45 kilometers north of the city. The erection of another cement factory, costing about Eth$15,000,000 and probably located in the Massawa area, is foreseen in 1965. It would have an annual output of 150,000 metric tons, primarily for export. In addition, a new factory for asbestos-cement products will be established, probably in or near Addis Ababa. The estimated power and energy requirements are shown in Table VII-24.

TABLE VII-24: POWER AND ENERGY REQUIREMENTS FOR PROPOSED CEMENT FACTORIES

Plant	Place	Requirements	
		kw.	kw.-hr.
Cement (70,000 metric tons)	Addis Ababa	1,400	11,000,000
Cement (150,000 metric tons)	Massawa	2,500	20,000,000
Cement products	Addis Ababa	100	210,000

By 1967, the total output of cement plants will have reached 210,000 tons with the full production, probably 250,000 tons, of the three primary plants to be realized shortly thereafter. Long range plans also include a cement factory at Bahir Dar.

Bricks. In 1957, 5,670,000 bricks were produced, which increased to 8,000,000 in 1962. Total production is forecast to reach 30,000,000 by 1967. This will be accomplished by the erection of new brickyards, total capacity of which will be 20,000,000 bricks annually. Electric power requirements will be limited to motor loads, the main heat source being nonelectrical. During the period 1967-1970, it is planned to construct a refractory materials plant to meet the needs of the metallurgical and other industries. Modern technique requires the use of electric furnaces to produce high quality refractories, such as will be required for boiler linings and locomotives, open hearth steel furnaces, heat-treating furnaces, and the glass and ceramic industry.

Lime. Lime factories are proposed which will produce 5,000 metric tons annually. Suitable limestone deposits exist in many areas of the Empire. Electric power requirements will be for motor loads, and if a rotary kiln is used the amount of power required will be about 550,000 kw.-hr. per year (70 kw.) by the end of 1967, if the goals of the Second Five Year Development Plan are realized.

Porcelain. During the period 1967-1970, a porcelain factory will be established to manufacture porcelain items for electrical products, primarily insulators of all types and porcelain parts for switches, receptacles, and fixtures. The capacity of the factory has not been fixed. Kaolin clays have been located by USBR geologists in or near the Giamma canyon, not far from Addis Ababa. A tunnel kiln will probably be used, and fuel is generally oil, coal, gas, or even electricity. At present, Ethiopia would have to import these fuels, except for electricity. Considering the small plant required initially, electricity may be used and would require 4,000,000 kw.-hr. annually at 450 kw. for three-shift operation to produce 500 metric tons of porcelain products per year. A total of 13 new plants will be erected or started during the period 1962-1967, devoted to producing mineral products for the building and nonmetal industries.

Iron and Steel. Except for the iron ore deposit in Eritrea Province, a domestic commercial supply of iron ore was not known to exist in inland Ethiopia as of 1962, but government planners are confident that a comprehensive prospecting program will reveal iron ore deposits in the future; thus they are hopeful that before the end of the five-year period 1962-1967 a steel plant with a forecast capacity of 80,000 metric tons output will be built. This, together with the Akaki Iron Works, completed in 1962 with an annual output of about 20,000 metric tons (using scrap iron), should be sufficient to start a metal and electric products industry which will serve the basic needs of the country. On this basis, these plants may be erected by 1967:

Agricultural Machine and Tool Factory
Metal Processing Plant
Metal Construction Plant
Household Appliance Plant
Tractor and Motor Car Assembly Plant
Aluminumware Factory
Electro Installations Factory
Electric Light Bulb Factory

By 1967, the following additional plants may be started:

Metal Processing Plant No. 2
Shipyard
Electric Motor Factory
Electric Wire and Cable Factory
Ship Repair Plants
Automobile Battery Factory
Steel Mill (discussed above)

All told, 15 new factories will be completed or started by the end of 1967 in this particularly industrial segment, and all will have substantial electrical power and energy requirements which will steadily increase in the future. Maximum power and energy requirements for these 15 new factories, when completed, cannot be definitely determined at this time, as plant output was not established in all cases in 1962. However, using data available, the maximum requirements are estimated in Table VII-25.

Miscellaneous

Tobacco. In 1957, about 252,000,000 cigarettes were produced, and in 1962 this increased to 370,000,000 with the proposed production in 1967 to reach 500,000,000. This will be accomplished by constructing one additional factory, probably to be started very late in the plan. Small motor loads are anticipated.

Printing and Publishing. Existing plants are to be expanded and one new plant of larger capacity is to be constructed by 1967. Small motor and some minor heating loads will develop, perhaps 50 kw. and 450,000 kw.-hr.

Other (Transport and Communications). This sector of the economy includes railways, road transport, air transport, water transport, city traffic, postal system, and radio and telephone communication facilities. Electricity requirements for these facilities up to this time have been limited to control of city traffic, airports, harbors, and the radio-telephone communication facilities and, in total, have been rather modest.

A ship repair plant at either Massawa or Assab is likely with the gradual development of the Imperial Ethiopian Navy. An estimate of annual energy requirements is about 470,000 kw.-hr. with a maximum demand of 225 kw., using a one shift per day operation.

The Addis Ababa International Airport, going into initial operation in 1963, will have a demand of 800 kw. and will require

215

TABLE VII-25 - ESTIMATED POWER REQUIREMENTS FOR FACTORIES PLANNED BY 1967

Plant	kw.-hr.	Maximum kw. demand
Steel Plant, 80,000 tons	32,000,000	3,650
Agricultural Machine Tool Factory	845,000	300 1/
Metal Processing Plant	4,000,000	600 2/
Metal Construction Plant	260,000	40 3/
Household Appliance Plant	260,000	90 4/
Tractor Assembly Plant	580,000	225 5/
Ship Repair Plants	1,000,000	450 6/
Aluminumware Factory	200,000	75 7/
Automobile Battery Factory	200,000	65 8/
Electro Installations Factory	200,000	65
Electric Light Bulb Factory	200,000	65
Metal Processing Plant No. 2	8,000,000	1,200 9/
Shipyard	6,000,000	750
Electric Motor Factory	440,000	150 10/
Electric Wire and Cable Factory	600,000	375 11/

Estimated Capacities:

1/Output 2,500 tons, 3 shifts.
2/Rolling mill, 18,000 tons, 3 shifts.
3/Structural steel, 600 tons, 3 shifts.
4/Iron cooking utensils, 400,000 pieces annually, 120 hp., one shift.
5/Eth$2,000,000 investment assumed, 1 shift.
6/Two plants (Massawa and Assab), 1 shift.
7/Aluminum cooking utensils, 300,000 items annually, 1 shift.
8/Annually 12,000 units, using 4,000 gallons oil per year in addition.
9/Rolling mill, 36,000 tons.
10/Annually 3,000 motors of 1/6 to 10 hp., 200 hp. connected load.
11/Copper wire, 120 tons annually, 500 hp. connected load.

about 3,500,000 kw.-hr. annually. The new LWF radio station will require 600 kw. and 2,500,000 kw.-hr. annually and will begin full scale broadcasts in 1963. I.B.T.E. radio station will require 600 kw. and 2,500,000 kw.-hr. and will begin broadcasting during the period 1963-1967.

The rate of growth of this sector is forecast to average over seven percent annually during the period 1962-1967, as compared with the total economy increase of four or five percent. The emphasis of this sector is in anticipation of the expanded industrial production, volume of trade, and marketable agricultural products.

The present railway transport is carried by two narrow-gage railroads--the Djibouti-Addis Ababa railway and the Massawa-Asmara-Agordat railway in Eritrea, both of which have been discussed in an earlier section. Government planners during the period 1962-1967 will prepare studies and designs to construct new railraods--Nazret-Dilla, Agordat-Tessenei, and Awash-Tendaho-Assab. Railway electrification requires a high traffic density in order to justify the installation, as the initial investment required is high. Therefore, the immediate prospects for electrification are very unlikely. However, from the long range viewpoint, electrification of some road sections is a possibility. This will be particularly true if the major source of energy in the Empire continues to be water power. The Awash-Tendaho-Assab road may become a principal transportation artery in the Empire and may eventually be electrified.

In Addis Ababa, planners have made a study of the city traffic problem with the recommendation that trolley bus transportation in combination with autobus be installed, and this project would be initiated in the period 1963-1967. The trolley buses would be driven by electric motors, and this selection was made on the basis of the configuration of the terrain in the city and an abundance of electric power, as well as the growing demand for city transport. The introduction of trolley buses was thus justified on economic grounds by the planners. Specific data are not available as to the number of trolley buses to be placed in operation, but estimates can be made based upon several factors, including the number of autobuses now being used. A substantial amount of electric energy will be required.

Emphasis is being placed upon lake and river transportation. In 1962, the only water transport was on Lake Tana and on the Baro River and that only partially developed. Inland water transportation facilities are to be expanded in the future with special emphasis placed upon Lake Tana to provide for the rapid development of Bahir Dar and other settlements along the lake. Opening of traffic on Lake Abaya (Lake Margharita) is planned in

connection with the fishing industry scheduled there. Electric power needs will be limited to navigation (lighthouses), dockside, and maintenance requirements and will be very modest for several years.

The expansion of the postal system and telecommunications facilities will not require substantial amounts of electricity, since it will be limited to the needs of the new buildings required, with minor amounts for the telephone system.

Domestic airports throughout the Empire are to be improved to accommodate all types of propeller-driven and small jet aircraft. With two or three exceptions, the domestic airports in 1962 were mainly grass strips to accommodate DC-3 or C-47 cargo planes. Government planners foresee an improvement of these airport facilities, and it is not unlikely that many within the next 15 or 20 years will have modern facilities, including night lighting. Demand should reach 2,000 kw. and energy requirements approach 9,000,000 kw.-hr. per year.

Public Consumption and Illumination

The south Eritrea load area, except for Assab, is sparsely settled, and there will be a negligible amount of energy sold in rural areas. Residential load for Assab will increase when and if a small industrial complex becomes firmly established around that town. The industrial load will become noticeable beginning in 1965 with the initial production from the Assab oil refinery and will become prominent by 1975 if the nucleus of a chemical industry is developed there. Also, the tourist industry in Ethiopia will develop in the future, and Assab will share in this, thus affecting power loads. The pleasant beaches, warm water, and continual ocean breeze will offset to some degree the high summertime temperatures.

A good estimate of Assab's population is not available, but a figure of 9,000 (1962) has been given. Considering the population increase that should result from increased port activities and a newly established petro-chemical industry, the loads have been estimated as shown in Table VII-47 (see "Estimated Future Need for Additional Generator Capacity--1964-1967").

The Addis Ababa load center complex contains the heart of the Ethiopian industrial empire. It is here that present industrial developments are concentrated and probably most future development will be here also. Because of its size and political importance, Addis Ababa has good prospects for continued growth in population and as a source of labor for industry.

This is the main electrical load center and far exceeds anything else in the country. The 450,000 population of Addis Ababa

in 1962 compares with the next largest city of Asmara, which has an estimated population of 100,000. These two probably will not be served from a common, interconnected, electrical system in the foreseeable future.

Addis Ababa has the bulk of the foreign population, whose per capita use of electricity will range from 50 to 250 kilowatt-hours per month, making use of all types of electrical appliances.

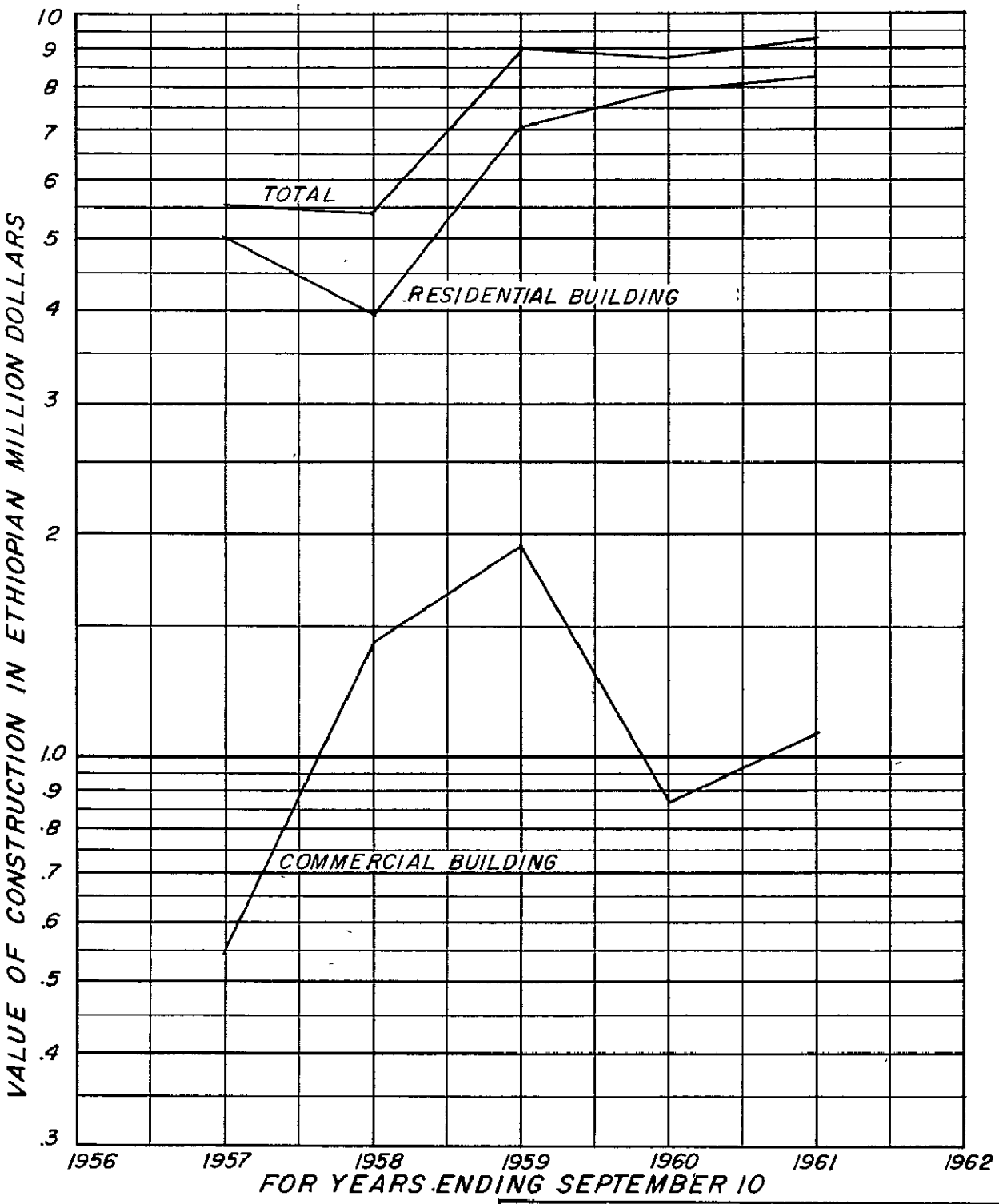
Institutions of higher learning established in Addis Ababa continue to attract young people, and the continued migration of people from the traditional agricultural areas to this city indicates that the population will experience a continued and substantial growth in the future. This, along with the per capita income in Addis Ababa (higher than that of the rest of the country), will mean a continuing increase in demand for electrical power to serve residential areas and also to supply the needs of many government buildings. Residential building construction has developed at a very rapid rate in comparison to commercial building construction. In 1961, nearly 90 percent of the construction was for residential needs, as shown by Drawing No. 4.0-BN-35.

An ambitious program of street and highway illumination in this area has greatly increased the demand for electricity for this purpose, but the total energy used is not separated from other use categories.

Sales of electricity to farms are negligible. Most farms are subsistence type enterprises with a very few devoted to truck farming, supplying vegetables to the Addis Ababa markets which in turn sell most of this to the foreign population. Plantation type operations afford little opportunity for electrical service now, but in the future may offer a possible outlet for power generated by Blue Nile River Basin powerplants.

Combined annual use of electricity by residential and government buildings and by public street lighting and other public authorities (schools) should develop in the future as shown on Table VII-35 (see "Losses").

Other provincial load areas in or adjacent to the Blue Nile River Basin under Case B include Dessie, Lekkemt, Jima, and Agere Hiywet (Ambo). Some of these areas have been mentioned as possible sites for certain types of industrial establishments. For the most part, with the possible exception of Dessie, these areas will depend almost entirely upon the surrounding agricultural economy. The future potential demands for electricity for rural



NOTES

1. Data not avilable for other locations but probably it presents 80% of construction in the Empire including Eritrea
2. Source: Municipality of Addis. Ababa

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST. AGENCY FOR INT DEV. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

BUILDING CONSTRUCTION
ADDIS ABABA

DRAWN C. L. CURTIS ... SUBMITTED. C. L. C.
TRACED MASRESHA ... RECOMMENDED P. W.K.
CHECKED C.L.C.-G.V.J. APPROVED C. E. B.

Addis Ababa Ethiopia MAY 30, 1962 4.0-BN-35

220

use adjacent to these centers will be very limited and will be used only by plantation type farms, if they should develop.

The potential demand for electricity in the public consumption and illumination category will be limited to residential and government buildings and to public streets and security lighting. As the standard of living is raised, the demand for electricity by the residents of these towns will increase but initially will be limited primarily to lighting loads. Sales to public authorities, such as schools, will also increase as more schools are introduced in these outlying areas. The nature of the loads will result in a generally low annual load factor, even in the foreseeable future. A breakdown of loads by classifications follows in a subsequent section.

Present Electric Rates

Generally, Ethiopia can be divided into two principal electric rates areas. The largest is the 13 provinces and the southern part of Eritrea, served principally by the Ethiopian Electric Light and Power Authority (EELPA). The other is the north Eritrea section, served principally by the Societa' Elettrica Dell' Africa Orientale (SEDAO).

The Blue Nile River Basin and adjacent areas fall within the marketing area of the EELPA, and as such the rate schedule of that authority will be of primary interest. Electric rates recently underwent a substantial reduction with the advent of the Koka Project hydroelectric power, which made a large block of more economical hydroelectric energy available for the first time in Ethiopia. Several small thermal and hydro units are operated in and adjacent to the Blue Nile River Basin. The reduction in rate throughout the area served by the EELPA resulted in subsidizing the higher unit cost of power generated at some of the smaller thermal and hydro units. In this way, the lower rates throughout the system encouraged greater use of electricity, and sales of electricity have increased greatly with the advent of the Koka power. As shown by Table VII-26, the present rates (1962) call for 15 cents per kilowatt-hour for the first 100 kilowatt-hours per month and 10 cents per kilowatt-hour for all use in excess of that during the same period. This is for the General Tariff classification, which includes residential service.

Cost of Electricity and Other Energy Sources

The cost of electricity can be considered in three general categories: (1) Large hydroelectric installations (Koka);

221

TABLE VII-26 - TARIFF IN FORCE, ETHIOPIA ELECTRIC LIGHT AND POWER AUTHORITY

Tariff classification	Sales price
General tariff:	
For the first 100 kw.-hr. per month	15 cents/kw.-hr.
For all consumption exceeding 100 kw.-hr. per month	10 cents/kw.-hr.
Commercial and industrial tariff:	
Fixed charge per kw. of maximum demand per month given by the maximum demand meter	Eth$5.00
For the first 1,000 kw.-hr. per month	10 cents/kw.-hr.
For all consumption over 1,000 kw.-hr. per month	5 cents/kw.-hr.
Off-peak tariff:	
For all off-peak energy	5 cents/kw.-hr.
Service charge:	
Single-phase per month	Eth$1.00
Three-phase per month	Eth$5.00

Special tariff:

Range of monthly kw.-hr. consumption	Percent reduction on total price	
	Normal consumers	Off-peak non-seasonal consumers
100,000-400,000	5	10
400,000-700,000	10	20
700,000-1,000,000	15	30
above 1,000,000	20	40

Note: Consumers under off-peak tariff have to sign special agreement with the EELPA, and each single case will have to be considered prior to approval.

222

(2) steam-electric generation (Addis Ababa); and (3) small isolated thermal installation (Bahir Dar).1/

(1) "By imposing an interest of 5 percent on the capital to be used for construction of the project, and amortization over 30 years for machinery, etc., and over 50 years for civil structures, and by calculating normal maintenance costs, the price for electricity produced at Koka and delivered in Addis Ababa and Dire Dawa will be about 2.15 cents per kw.-hr., provided an average of about 110 million kw.-hr. are delivered per year." Koka Hydroelectric Project, Imperial Ethiopian Government, December 1958.

(2) The Addis Ababa steam plant has a generator output of 5,000 kw. at site and has a maximum energy production of about 21,900,000 kw.-hr. with a load factor of about 50 percent.

The specific production costs at the plant vary from about 5.6 cents per kw.-hr. for full production to almost 11 cents for one-quarter production, as indicated by Table VII-27.

TABLE VII-27 - SPECIFIC PRODUCTION COSTS, ADDIS ABABA STEAM PLANT

Million kw.-hr./yr	In Ethiopian cents per kilowatt-hour					
	Fuel	Lub. oil	Personnel	Maintenance	Depreciation	Total
5.0	7.68	0.012	1.20	0.60	1.448	10.940
10.0	6.53	0.006	0.60	0.30	0.724	8.160
15.0	5.63	0.005	0.40	0.20	0.483	6.718
20.0	5.10	0.004	0.30	0.15	0.362	5.916
21.9	4.85	0.003	0.27	0.14	0.330	5.593

(3) The Bahir Dar diesel electric plant is typical of a small thermal plant serving a village area, and the total output of the station at the site is rated at 96 kw. with a load factor of about 40 percent. The maximum energy to be produced per year is about 336,000 kw.-hr. It was noted that the production cost per kw.-hr. ranged from almost 14 cents at full plant output to about 41 cents per kw.-hr. when loaded to about one-seventh of its maximum.

1/ Dessie and Jima costs would be slightly less.

223

Other energy sources include firewood, charcoal, petroleum products, and coal. Coal is an insignificant part of the total fuel sources used and can be neglected as a source of energy. An indication of the use made of different types of energy sources, by industry, can be obtained by comparing the costs of energy used by various segments of industry, as shown on Table VII-28.

TABLE VII-28 - COMPARISON OF ENERGY COSTS IN 1958 BY SEGMENTS OF INDUSTRY

Energy	Costs
Electricity from public utility services	Eth$1,146,000
Petroleum products	2,030,000
Charcoal	239,000
Firewood	239,000
Total	Eth$3,714,000

Fuel oil used to fire the boilers of the Addis Ababa steam plant cost Eth$128 per metric ton, f.o.b. Addis Ababa, while diesel oil delivered to Bahir Dar for operating the diesel electric plants there cost Eth$308 per metric ton, f.o.b. Bahir Dar. The Eth$299,000 expenditure for firewood was for the purchase of some 50,000 cubic meters, which would represent a cost of about Eth$6.00 per cubic meter. This was purchased by the manufacturing industries in 1958. During the same year, 4,000 metric tons of charcoal were purchased for Eth$239,000, representing some Eth$60 per ton. In 1958, the manufacturing industries used some 6,018 metric tons of petroleum products, consisting mainly of diesel and furnace oils, and this was valued at Eth$1,343,000. This was used mainly for generation of electric power for industry's own use. On the average then, this would have cost Eth$223 per metric ton. The Eth$6.00 per metric ton for firewood, as quoted from one source and as noted above, appears to be very low. Large quantities of firewood purchased by the USAID Mission in 1962 were about Eth$9.50 per cubic meter. This was in Addis Ababa. In other locations, such as Dire Dawa and Harar, Eth$2.90 per 100 kilograms was quoted,

which would amount to around Eth$14 per cubic meter. This, however, is for smaller lots. In a five-year period, 1958-1962, the cost of wood has increased 1.6 times in the Addis Ababa area.

The following Table VII-29 indicates that the most economical fuels are wood, charcoal, furnace oil, and diesel oil in the order indicated.

TABLE VII-29 - ENERGY COST OTHER THAN ELECTRICITY

Fuel	B.t.u./kg.	Cost Eth¢/kg.	B.t.u. for 1¢ (Eth)
Wood	15,400	2.9	5,310
Charcoal	28,160	6.0	4,693
Furnace oil	40,700	12.8	3,180
Diesel oil	41,250	30.8	1,340

The average cost of electricity from the utility serving the central provinces in 1962 was about eight cents per kw.-hr. (one kw.-hr. equals 3,413 B.t.u.). The number of B.t.u. per Ethiopian cent was 427. This, of course, is not in any way comparable with the last column in Table VII-29, as the conversion factors for combustion efficiency, handling costs, and other expenses associated with a commercial plant handling these fuels have all been omitted. Assuming the use of furnace oil for a steam-electric generating plant, and diesel oil in a diesel-electric plant, it was found that for a small type installation the cost of generating one kw.-hr. using furnace oil fuel, was Eth9.2¢, and the cost per kw.-hr. using diesel oil was Eth10.4¢. For a large hypothetical oil-fired steam-electric generating plant located near Akaki, the cost of production is slightly less than Eth5¢ per kw.-hr.

Diesel and furnace oils are imported items, whereas wood and charcoal are available locally. With the increasing demand, however, cost of local fuel has increased correspondingly over the past five years, with no indication that this trend will be changed. Generally, electricity, even at the present rates, is competitive with other forms of energy when considered from the industrial viewpoint. For domestic use, the low income groups will find wood and charcoal more economical than electricity for some time to come, although this will gradually change with time as the rates are lowered and the per capita income raised. For those in the higher income category, the other alternative to electricity is

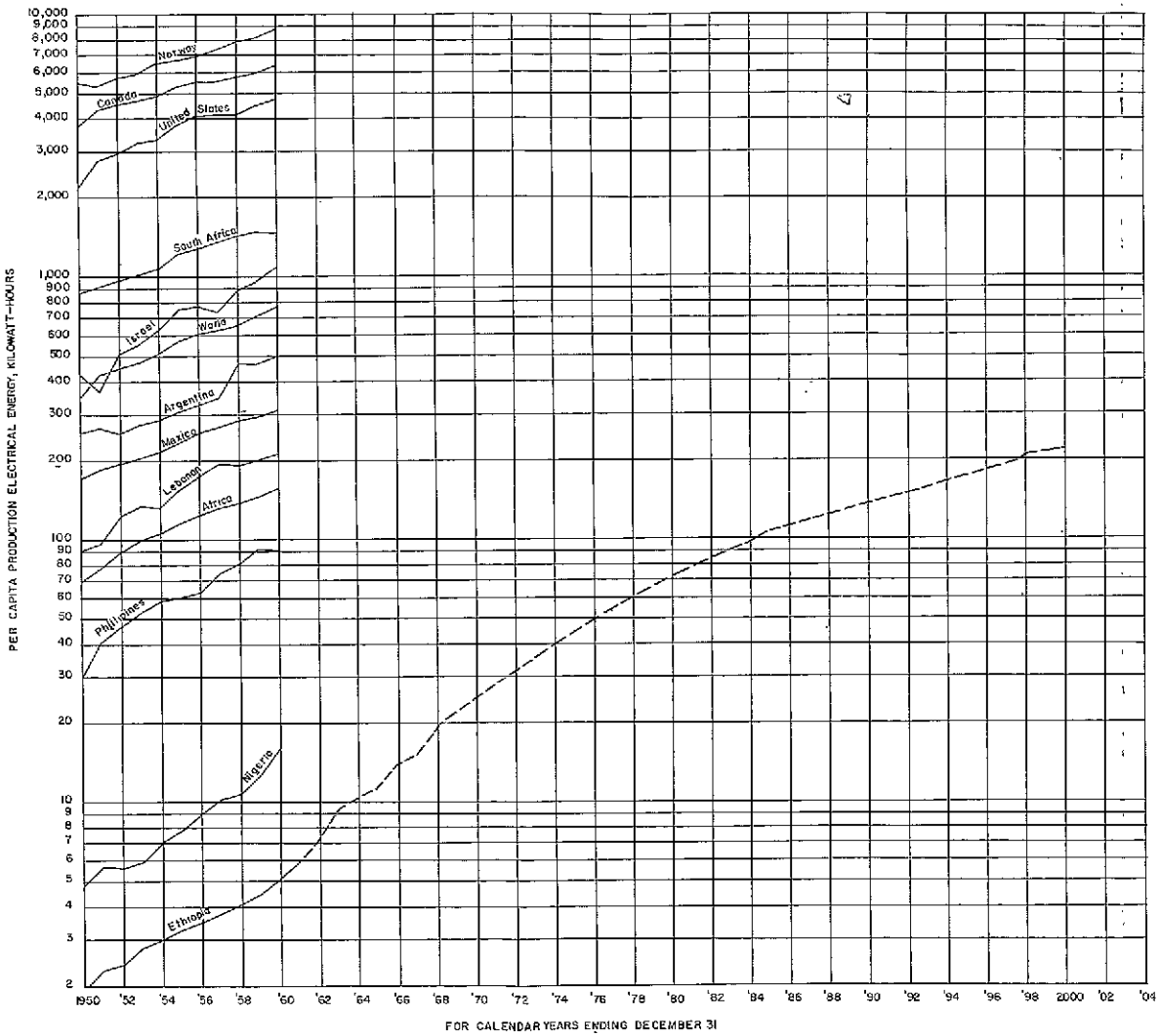
bottled gas; and, in this comparison, electricity at present rates is competitive with gas for residential and small commercial purposes.

Firewood is not always available. Charcoal is shipped into those areas where wood is not readily available, and the price varies considerably, being directly influenced by transportation costs. Fuel oil and diesel oil and related petroleum products have prices influenced by transportation costs that vary in different parts of the Empire.

A high percentage of the village and rural population depends upon cow dung for domestic fuel requirements. If this type of fuel were not available, the demand for charcoal and wood would greatly increase, driving the price upward practically out of reach of the lower income groups. As living standards and per capita income increase in the future, the lower income village and rural groups will turn to other traditional fuels, such as petroleum products, wood and charcoal, and electricity. The prices of wood and charcoal will continue to increase in the future, but the cost of electricity should actually decrease. The world trend in use and price of petroleum products has had a tendency to rise, partly because these products are a convenient taxation vehicle. Therefore, the conclusion is reached that electricity from hydroelectric sources offers the most stable, long-range energy source, both as to supply and as to price.

Past, Present, and Estimated Future Power Requirements

An insight into the magnitude and degree of electrification of a country is helpful when considering some aspect of the power supply problem. Ethiopia has about the lowest per capita electrical energy production in Africa--about 3 kw.-hr. per capita in 1954. In 1961 this had doubled to about 6 kw.-hr. and by 1965 should again double to about 12 kw.-hr. This corresponded to something over 100 kw.-hr. per capita for Africa as a whole in 1954 and about 500 kw.-hr. per capita for the world. In 1961 Africa produced 157 kw.-hr. per capita, and the world average was 766 kw.-hr. Drawing No. 4.0-BN-79 illustrates this trend and shows the production for Ethiopia increasing over 11 times to around 70 kw.-hr. per capita by 1980. Drawing No. 4.0-BN-151 shows the world power data for 1961 for the more advanced countries, led by Norway, Canada, Sweden, and the United States in that order.



1960
POPULATION ESTIMATES

Lebanon	1,646,000
Israel	2,114,000
Norway	3,587,000
South Africa	15,841,000
Canada	17,814,000
Ethiopia	19,950,000
Argentina	20,956,000
Philippines	27,456,000
Nigeria	34,296,000
Mexico	34,626,000
United States	180,670,000
Africa	254,000,000
World	2,955,000,000

LEGEND

——— Per capita historical electrical energy production

– – – – Forecast of per capita electrical energy production requirements in Ethiopia based on studies of loads and population estimates

ETHIOPIA UNITED STATES COOPERATIVE PROGRAM
FOR THE
STUDY OF WATER RESOURCES
IN COOPERATION WITH
U.S. DEPT. OF STATE AGENCY FOR INT DEVELOPMENT AND U.S. DEPT. OF INTERIOR BUREAU OF RECLAMATION

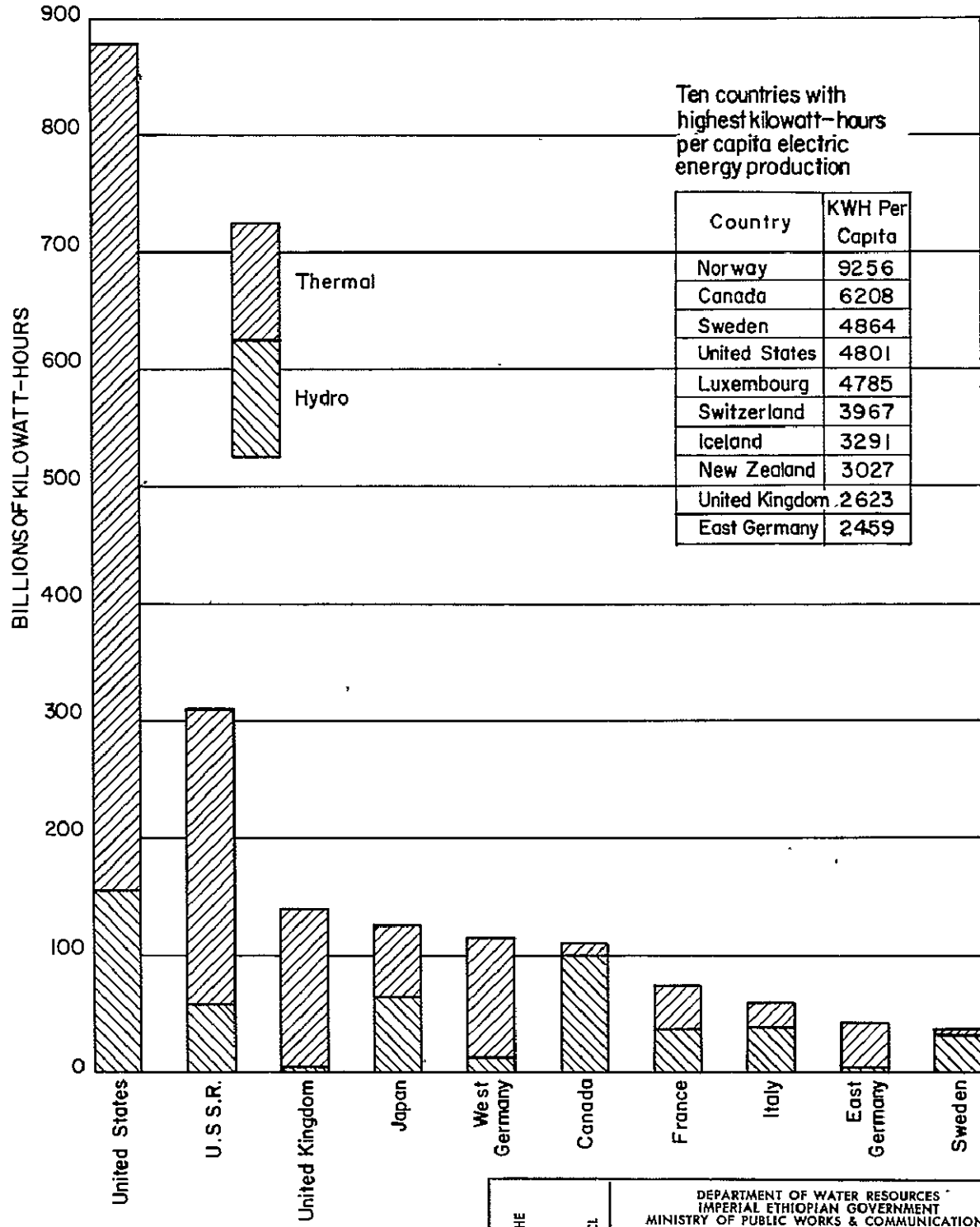
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

ESTIMATED FUTURE PER CAPITA ELECTRICAL ENERGY PRODUCTION REQUIREMENTS IN ETHIOPIA

DRAWN S.L.S. SUBMITTED C.L.C.
TRACED A.M.M. RECOMMENDED P.W.K.
CHECKED C.L.C. - G.V.J. APPROVED G.E.B.

Addis Ababa Ethiopia DEC 28, 1962 | 4 0-BN-79



Ten countries with highest kilowatt-hours per capita electric energy production

Country	KWH Per Capita
Norway	9256
Canada	6208
Sweden	4864
United States	4801
Luxembourg	4785
Switzerland	3967
Iceland	3291
New Zealand	3027
United Kingdom	2623
East Germany	2459

SOURCE: ELECTRICAL WORLD

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., A.I.D. AND U.S. DEPT. OF INT., BUR. OF RECL

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

WORLD POWER DATA—1961

DRAWN G. V. J. SUBMITTED C.E.C.
TRACED A. N. M. RECOMMENDED P.W.K.
CHECKED C.L.C. APPROVED C.E.B.

Addis Ababa Ethiopia May 3, 1963 | 4.0-BN-151

228

System Conditions Considered for this Study

The heart of Ethiopia's industry--its main load area--is the Addis Ababa Complex (63.9 percent of total national production for load in 1962). This is the fastest growing area, where the supplier may be hard pressed to construct new facilities rapidly enough to meet the growing load demand. The Finchaa Sub-Basin potential hydroelectric facilities are conveniently located adjacent to this load area and can be considered as potential production facilities to meet future load requirements.

In this study, two conditions are considered--Case A and Case B--with the first condition, Case A, considering that there will be no major interconnections during the period of review, and with Case B assuming interconnections as follows:

1974: Lekkemt
Agere Hiywet (Ambo)
Jima

1977: Dessie
Assab

This particular study extends through 1980.

Existing Power Systems

Powerplants. The present interconnected system (Addis Ababa Complex) has five powerplants, some of which are maintained as reserve capacity as noted from Table VII-30. The 1961 (existing) Interconnected System serving the Addis Ababa Complex is as shown by Drawing No. 4.0-Et-13.1/

By far the greatest source of energy at present is Koka hydro which is served by a reservoir on the Awash River having a capacity of 1,500 million cu. m. Utilizing a head of 32 to 40 meters, the installed capacity consists of three generators, each rated at 18,000 kv.-a., or 54,000 kv.-a. total. The rated capacity at full load is 45 mw., but this includes one generator as a "spare." At the lowest reservoir level, the firm plant capacity, based upon two units, is regarded as 23 mw. as noted in Table VII-30. Koka powerplant may also be considered as "Awash No. 1." Drawing No. 4.0-BN-170 shows the Koka location.

1/Unchanged in 1963 except for loads.

TABLE VII-30 - 1961 INTERCONNECTED SYSTEM--ADDIS ABABA COMPLEX (CASES A AND B)1/

Name and type	Installed capacity (kv.-a)	Firm capacity (kw.)	Production capability (millions of kw.-hr.)		
			Good water years	Average water years	Adverse water years
Koka Hydro	54,000	23,000	120	110	90
Aba Samuel Hydro	8,250	4,750	27	23	18
Ourso Hydro	525	250	2	2	2
Addis Ababa Steam2/	6,250	(5,000)	0	10	30
Alemaya Diesel2/	2,910	2,000	1	5	10
Total	71,935	30,000	150	150	150

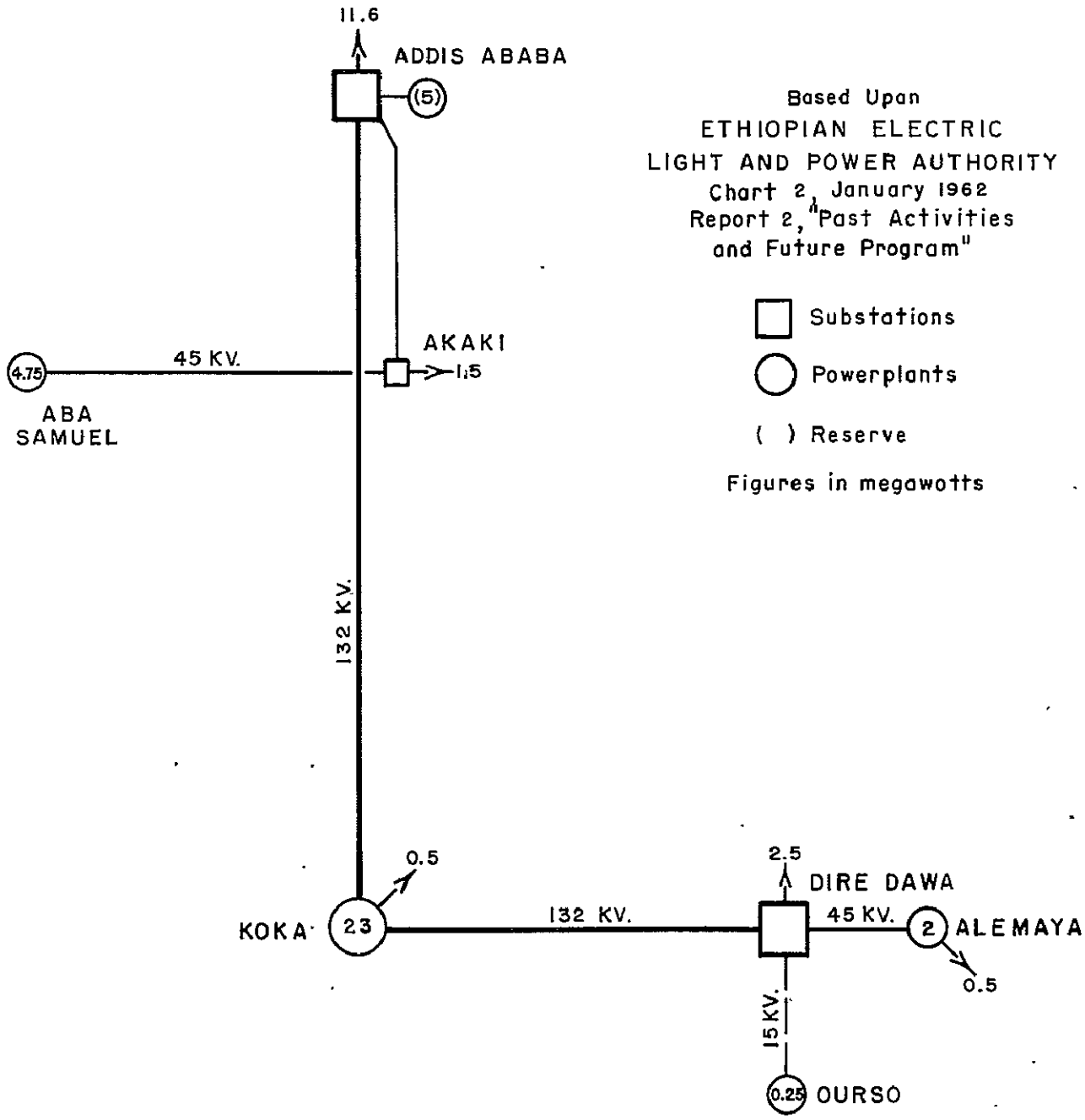
1/ Based upon January 1962 "Report--Past Activities and Future Programme," EELPA.
2/ Normally maintained as reserves in good water years; possible operation as shown in average and adverse water years.

Aba Samuel hydroelectric powerplant is about 35 km. south of Addis Ababa on the Acachi (Akaki) River, a tributary to the Awash. This was initially installed during the Italian Occupation in 1939. There are five generating units operating at 95 meters head (different sizes) providing a total rated capacity of 8,250 kv-a. or 6,600 kw. The reservoir has a storage capability of 60 million cu.m. Firm capability has been established as 4,750 kw.

The Ourso hydroelectric powerplant is 30 km. west of Dire Dawa and is served from a natural spring with no reservoir, having only forebay storage for a little regulation. It is rated at 525 kv.-a. with a head of 175 meters.

The Addis Ababa steam powerplant consists of one condensing steam turbine operating at a pressure of 29 kg. per sq. cm. at 425° C. and one 6,250-kv.-a. generator. It went into initial operation in 1957 and has been in standby since the early or middle part of 1960 with the advent of Koka power.

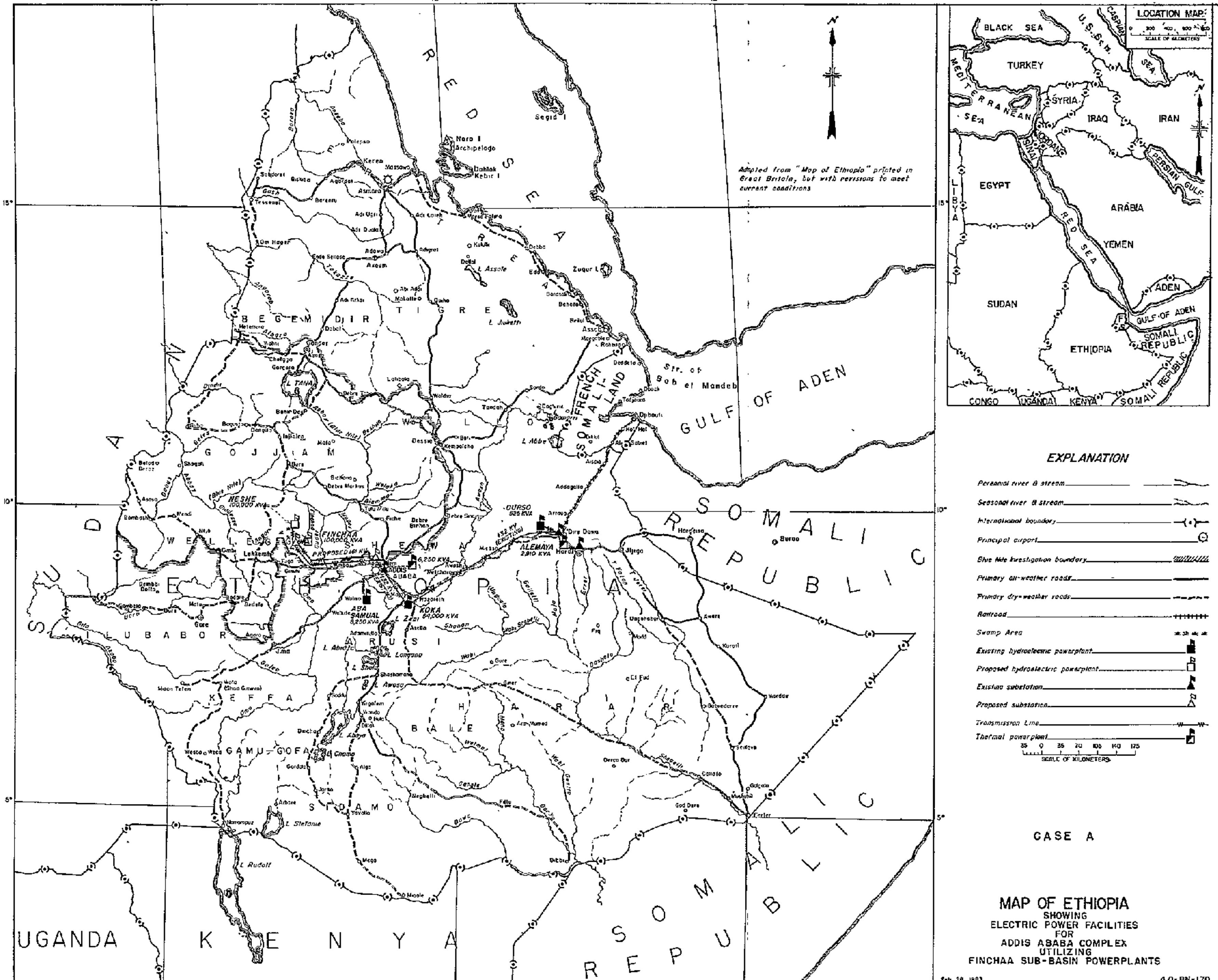
The Alemaya diesel powerplant is about 30 km. south of Dire Dawa. Three sets are installed with a total capacity of 2,910 kv-a. It began operation in 1958 parallel with Ourso. It went into reserve status at the beginning of 1961 when Koka power was made available to this area over the 132-kv. transmission line.



1961 EXISTING INTERCONNECTED SYSTEM
(ADDIS ABABA COMPLEX)

C.L.C.
4.0-Et-13

231



MAP OF ETHIOPIA
SHOWING
ELECTRIC POWER FACILITIES
FOR
ADDIS ABABA COMPLEX
UTILIZING
FINCHAA SUB-BASIN POWERPLANTS

Several isolated systems are operated, including Jima, Dessie, Agere Hiywet (Ambo), and Assab, with characteristics as indicated on Table VII-31.

TABLE VII-31 - 1963 ISOLATED SYSTEMS (CASE B)1/

Location	Installed capacity kv.-a.		Firm capacity (kw.)	Production capability (1,000 kw.-hr.)	
	Diesel	Hydro		Diesel	Hydro
Lekkemt	300 2/	--	--	--	--
Jima	1,125	170	600	2,400	300
Dessie	1,125	--	600	2,400	--
Agere Hiywet (Ambo)	--	210	100	--	350
Assab	1,375 3/	--	--	--	--

1/ Based primarily upon January 1962 "Report--Past Activities and Future Programme," EELPA.
2/ 150 kw. in 1962 and 150 kw. in 1963.
3/ 1,000 kw. added in 1963.

Transmission Lines. For the Interconnected System (summarized by Table VII-32), there were 418 km. of 132-kv. lines, 62 km. of 45-kv. lines, and 97 km. of 15-kv. lines--all steel tower except for the 15-kv., some of which is steel pole. Since 1961 some impregnated wood-pole 15-kv. lines have been constructed.

TABLE VII-32 - 1961 INTERCONNECTED SYSTEM--ADDIS ABABA COMPLEX (CASES A AND B)

Location	Voltage (kv.)	Length (km.)	Conductors		Capacity (kw.)
			mm^2	Type	
Koka-Addis Ababa	132	81	3 x 150	ACSR	40,000
Koka-Dire Dawa	131	337	3 x 150	ACSR	10,000
Koka-Nazret 1/	15	12	3 x 53	ACSR	1,000
Koka-Mojo 1/	15	17	3 x 53	ACSR	1,000
Aba Samuel-Akaki	45	17	3 x 22	Cu	5,000
Akaki-Addis Ababa	45	15	3 x 45	Cu	5,000
Akaki-Debre Zeyt 1/	15	23	3 x 53	ACSR	500
Ourso-Dire Dawa	15	30	3 x 12	Cu	250
Alemaya-Dire Dawa	45	30	3 x 22	Cu	2,500
Alemaya-Harar 1/	15	15	3 x 22	Cu	750

1/ Constructed for 45 kv.

233

The 132-kv. lines are operated with the neutral grounded by Petersen 1/ coils, while the 15- and 45-kv. lines have isolated neutrals.

Substations. There are three main high voltage substations in the Interconnected System totaling 39,100 kw. capacity as shown by Table VII-33.

TABLE VII-33 - 1961 INTERCONNECTED SYSTEM--
ADDIS ABABA COMPLEX

Location	Ratio (kv.)	Rating (kv.-a.)	Capacity (kw.)
Addis Ababa	132/15 45/15	2 x 22,000 4 x 1,500	18,000 5,000
Akaki (Acachi)	45/15	1 x 1,500) 1 x 630)	1,700
Dire Dawa	132/15 45/15	2 x 15,000 1 x 3,000	12,000 2,400

Past, Present, and Future Requirements

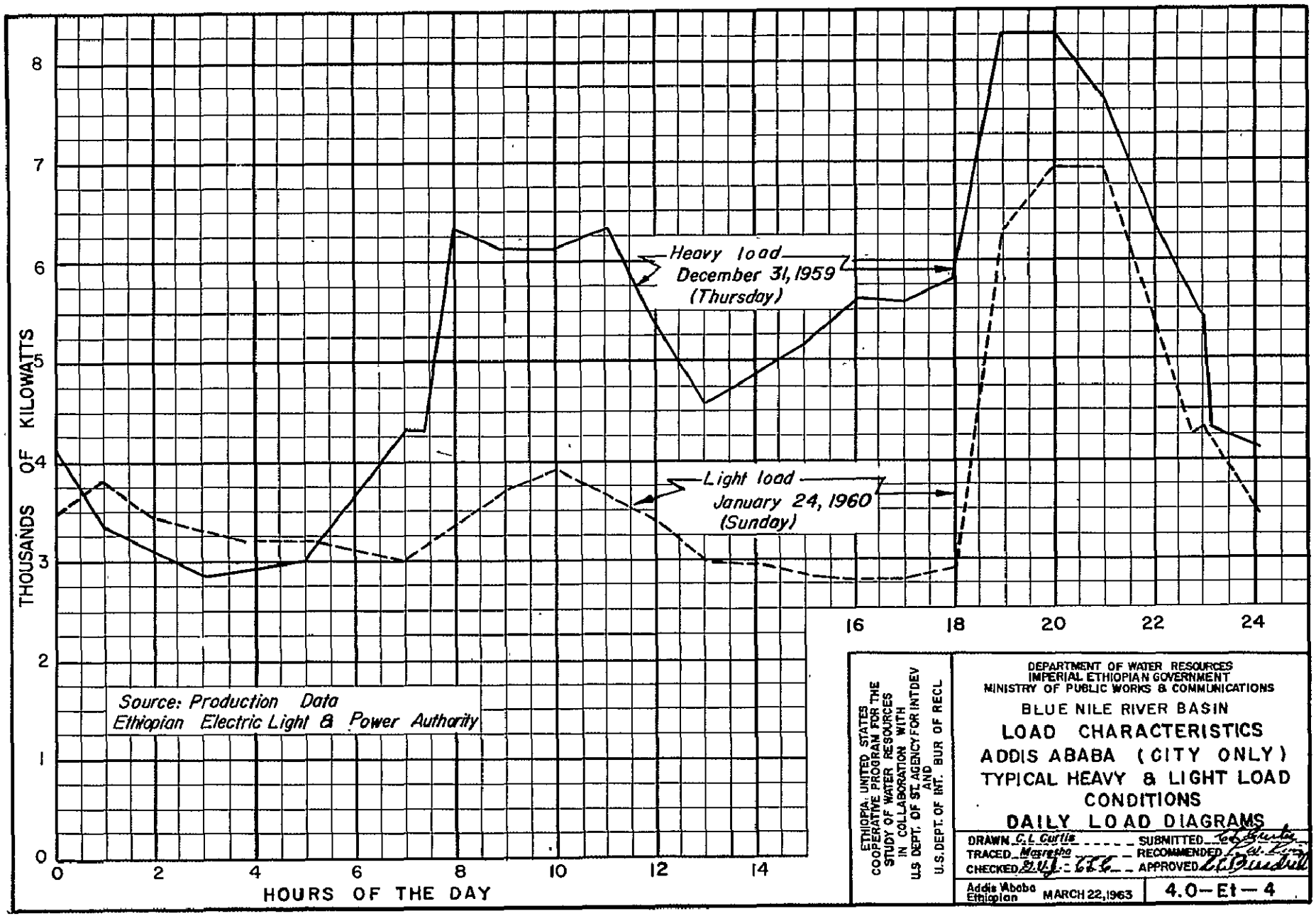
Load Centers. For both Cases A and B, the principal load center will be the Addis Ababa Complex. For Case B additional small load centers would be interconnected at specified future dates with the Addis Ababa Complex--those at Lekkemt, Agere Hiywet (Ambo), Jima, Dessie, and Assab. This does not imply that other load centers do not exist; rather, it indicates only that this study is concerned with those load centers likely to be served by the Finchaa Basin hydroelectric powerplants within a 20-year period. The Case A and Case B load centers are as indicated by Drawings Nos. 4.0-BN-169 and 4.0-BN-171, respectively.

Peaks and Monthly Distribution of Energy. The heaviest load in the Addis Ababa Complex (and for that matter, in Ethiopia) is the city of Addis Ababa, and the daily load diagrams for heavy and light load conditions are indicated by Drawing No. 4.0-Et-4. These diagrams do not necessarily imply that the heaviest and lightest loads occurred on the days indicated but are merely examples of a heavy condition and a light condition.

Two peaks seem to occur during the year--August and December--but not consistently so for several reasons. The year's peak seems to occur during the coldest part of the year, which is usually in

1/ Ground-fault neutralizers.

234


THOUSANDS OF KILOWATTS
0
1
2
3
4
5
6
7
8
HOURS OF THE DAY
0
2
4
6
8
10
12
14
16
18
20
22
24
Heavy load
December 31, 1959
(Thursday)
Light load
January 24, 1960
(Sunday)
Source: Production Data
Ethiopian Electric Light & Power Authority
ETHIOPIA. UNITED STATES
COOPERATIVE PROGRAM FOR THE
STUDY OF WATER RESOURCES
IN COLLABORATION WITH
U.S. DEPT. OF ST. AGENCY FOR INT DEV
AND
U.S. DEPT. OF INT. BUR OF RECL
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN
LOAD CHARACTERISTICS
ADDIS ABABA (CITY ONLY)
TYPICAL HEAVY & LIGHT LOAD
CONDITIONS
DAILY LOAD DIAGRAMS
DRAWN C.L. Curtis
TRACED Masresha
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
Addis Ababa Ethiopian
MARCH 22, 1963
4.0—Et—4

December. However, most of the precipitation occurring during the June 15 to September 15 rainy season falls in August, and in a "wet" year the coolness and dampness resulting from cloud cover at those high altitudes can also produce a high demand. Drawing No. 4.0-Et-5 indicates that for one particular period the kw. peaks occurred in the fall (November-December). However, in 1961-62 Drawing No. 4.0-BN-77 shows that the greatest monthly energy requirement occurred in August. This was a particularly "wet" year. For purposes of the Blue Nile studies,1/ the monthly distribution of the annual energy requirements was taken to be as shown by Drawing No. 4.0-BN-78, which shows the maximum requirement falling in December, and August demand as next heavier. This would apply to conditions as they may exist in 1980. It should be understood that there has been an insufficient operating period for the Interconnected System to establish a definite pattern at this time.

For weekly heavy load duration and peak percent curves, see Drawing No. 4.0-BN-118.

Past and Estimated Future Trends of Energy Requirements. A study of the past trend in energy requirements will be meaningless prior to 1960, as the tariff structure and availability of adequate supplies influenced a slower rate of growth than would otherwise have been the situation. In 1960, with the advent of Koka hydro-electric power and the revised tariff structure reflecting lower rates, the annual trend of energy requirements was upward.

A summary of past production of electrical energy by years from 1943 through 1962 is given in Table VII-34. In 1960, 99.99 percent of the total production by EELPA was for the Addis Ababa Complex (Interconnected System), whereas in 1961 the figure was 99.55 percent. Other production was in and for the isolated systems. These figures do not include the north Eritrea systems nor the industrial plants which have generating capacity for their own use.

1/ Operation studies prepared for the Finchaa Sub-Basin facilities assumed a constant monthly requirement equaling about 8.33 percent of the annual. This was done before definite data were obtained, which were not available following at least a year's operation of the Interconnected System starting in mid-1960. Other projects studied later use the distribution as shown by Drawing No. 4.0-BN-78.

TABLE VII-34 - PAST TRENDS OF ENERGY REQUIREMENTS (EXCLUDING ERITREA AND PRODUCTION BY INDUSTRIAL FIRMS)

Interconnected and Isolated Systems					
For year ended Sept. 10	Production (in millions kw.-hr.)			Percent annual increase	Remarks
	Hydro	Thermal	Total		
1943	5.923	1.882	7.805	-	
1944	6.574	1.587	8.161	4.5	Source: EELPA as reported in Ethiopian Economic Review, Nos. 5 and 6.
1945	7.857	1.545	9.402	15.2	
1946	10.057	1.324	11.376	20.0	
1947	11.692	1.330	13.024	14.4	
1948	12.628	1.651	14.279	9.6	
1949	13.658	2.106	15.764	10.3	
1950	14.012	2.868	16.878	7.0	
1951	15.259	3.295	18.554	9.9	
1952	16.608	4.003	20.611	11.0	
1953	19.548	4.486	24.034	16.6	
1954	22.578	4.187	26.745	11.3	
1955	25.980	5.359	31.339	17.1	
1956	25.115	7.954	33.070	5.5	
1957	31.217	5.595	36.812	11.3	
1958	25.740	14.971	40.719	10.6	
1959	27.768	19.333	47.101	15.7	
1960	46.744	8.689	55.433	17.7	Koka on line.
1961	68.106	6.316	74.422	34.3	
1962	--	--	96.500	29.7	

The electrical energy produced for the Addis Ababa Complex (EELPA) as a percent of the total production in the Empire was approximately as follows:

1957	50.2 percent
1958	51.5
1959	53.2
1960	54.4
1961	59.6
1962	63.9

The remainder of the production was by industrial firms for their own use and in north Eritrea, principally by SEDAO in the Massawa-Asmara area.

To forecast the future trend of energy requirements for the Addis Ababa Complex, the best source for the period through 1971 is

237

LOCATION	1951 (1958-59) Average Load in KW	Peak Load in KW	Load Factor	Power Factor	1952 (1959-60) Average Load in KW	Peak Load in KW	Load Factor	Power Factor	1953 (1960-61) Average Load in KW	Peak Load in KW	Load Factor	Power Factor	Peak demand in KW
ADDIS ABABA (CITY ONLY)	4113	8000	0.514	0.84	5002	9300	0.538	0.87	5200	10200	0.510	0.885	10200 * on Hidar 1953 (Nov. 1960)
DIRE DAWA & HARAR	366	1230	0.298		452	1300	0.348		731	1700	0.430		1700 * on Tahsas 1953 (Dec. 1960)
NAZARETH	175	257	0.680	0.80	184	300	0.613	0.86	157	320	0.491		320 * on Hidar 1953 (Nov. 1960)
JIMA	86	195	0.441		104	305	0.341		105	365	0.288		365 on Meskerm 1953 (Sept. 1960)
DESSIE	55	135	0.407		59	270	0.218		97	360	0.269		360 on Tahsas 1953 (Dec. 1960)
GONDAR	37	100	0.37		40	140	0 286		52.5	150	0.350		150 on Tahsas 1953 (Dec. 1960)
AGERE HIYWET (AMBO)	27.6	65	0.425		28	92	0.304		32	85	0.376		92 on Guenbot 1952 (May 1960)
DEBRE BIRHAN	31	75	0.413		35	75	0.467		35	75	0.467		75 KW
YIRGALEM					14	43	0.326		23	64	0.359		64 on Hidar 1953 (Nov. 1960)
DEBRE MARKOS					12.7	30	0.423		16.4	34	0.482		34 on Tekemte 1953 (Oct. 1960)
JIJJIGA					22.4	36	0.622		23.6	38	0.621		38 on Tahsas 1953 (Dec. 1960)
BAHIR DAR									10	32	0.313		32 on Meskerm 1953 (Sept. 1960)

NOTES:

1. Data from Ethiopian Electric Light and Power Authority.
2. Dates are according to Ethiopian calendar with parenthetical entry in equivalent Gregorian calendar.

* Part of Addis Ababa Complex.

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

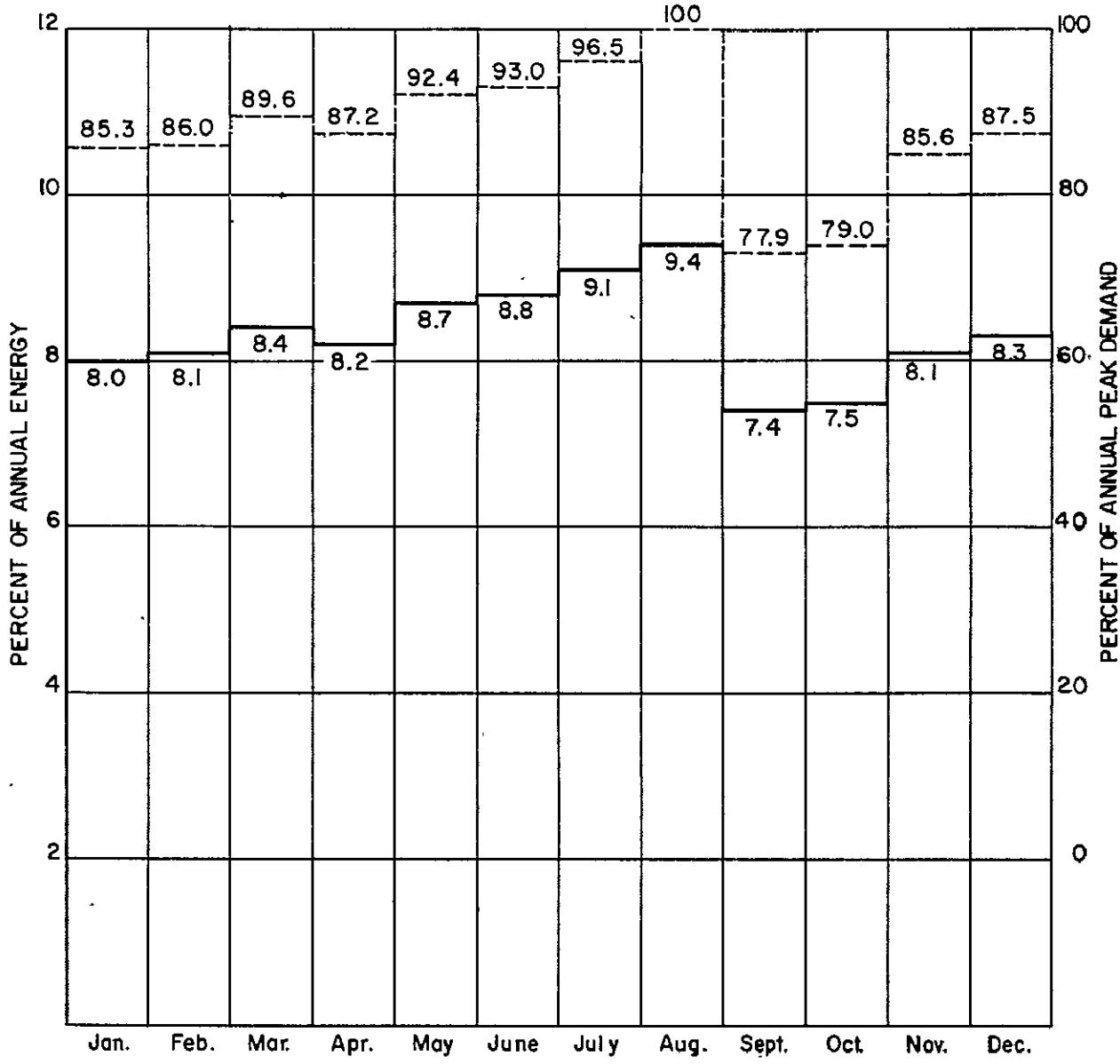
BLUE NILE RIVER BASIN

LOAD CHARACTERISTICS

PRINCIPAL CITIES-ETHIOPIA (EXCLUSIVE OF ERITREA)

DRAWN C.L.C. SUBMITTED
TRACED A.N.M. RECOMMENDED
CHECKED APPROVED

Addis Ababa Ethiopia | Mar. 23, 1963 | 4.0-Et.-5



——— Percent monthly energy of annual energy

– – – – – Percent monthly peak of annual peak demand

Annual load factor 55 percent

For period September 1961 through August 1962,

Koka Interconnected System.

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH A.I.D. U.S. DEPT. OF ST., AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

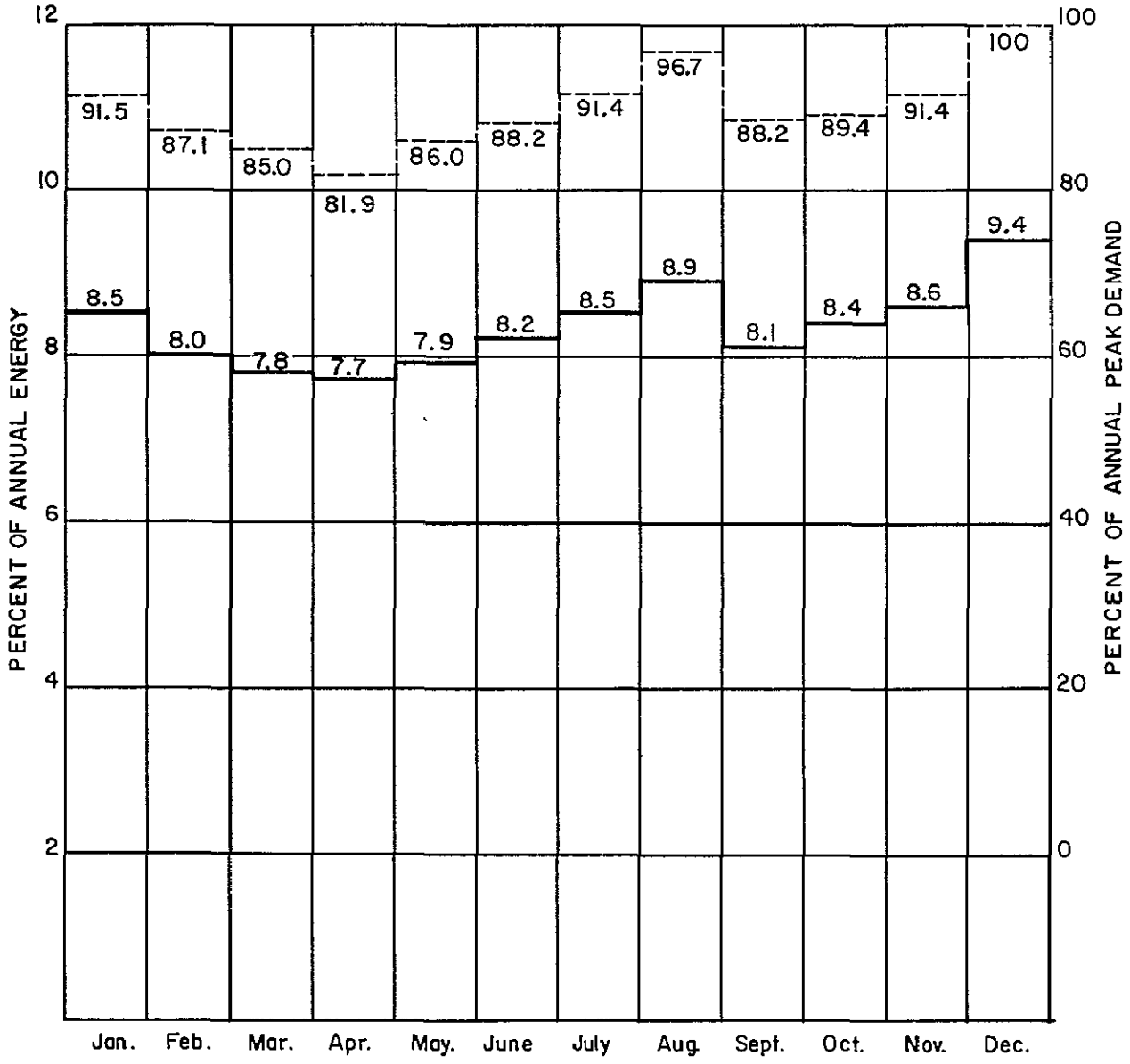
BLUE NILE RIVER BASIN

1961-62 LOAD CHARACTERISTICS MONTHLY DISTRIBUTION INTERCONNECTED SYSTEM

DRAWN C.L.C. SUBMITTED C.L.C.
TRACED A.N.M. RECOMMENDED P.W.K.
CHECKED C.L.C. APPROVED C.E.B.

Addis Ababa Ethiopia Dec 14, 1962 | 4.0-BN-77

239



——— Percent monthly energy of annual energy.

– – – – Percent monthly peak of annual peak demand.

Annual load factor 60 percent.

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., A.I.D. AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

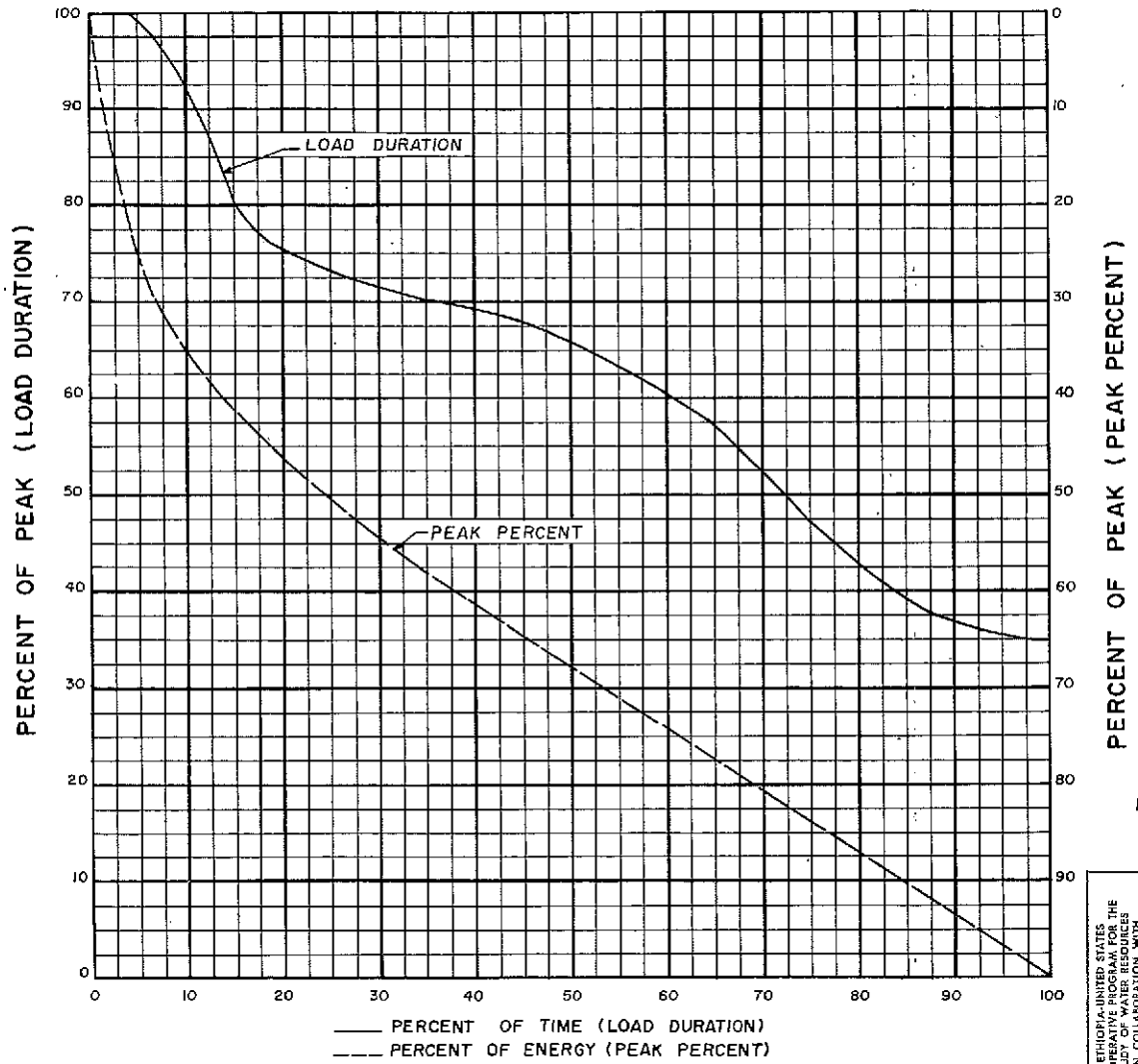
BLUE NILE RIVER BASIN

FUTURE LOAD CHARACTERISTICS MONTHLY DISTRIBUTION INTERCONNECTED SYSTEM

DRAWN C.L.C. SUBMITTED C.L.C.
TRACED A.N.M. RECOMMENDED P.W.K.
CHECKED C.L.C. APPROVED C.E.B.

Addis Ababa Ethiopia. Dec 24, 1962 | 4.0—BN—78

260



PEAK LOAD WEEK IN DECEMBER

ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., AGENCY FOR INT. DEV AND U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN
FUTURE LOAD CHARACTERISTICS
LOAD DURATION & PEAK PERCENT CURVES
HEAVY LOAD CONDITIONS
INTERCONNECTED SYSTEM
(EXCLUDING ERITREA)

DRAWN C.L.C.	SUBMITTED C.L.C.
TRACED ASSEFA A.	RECOMMENDED P.W.K.
CHECKED C.L.C.	APPROVED C.E.B.

Addis Ababa Ethiopia MARCH 22, 1963 | 4.0—BN—118

the EELPA, which has indicated that the annual growth rate will be 22 percent through 1966 and will taper off to 17 percent by 1971. This is for the general, industrial, and commercial requirements but does not consider certain possible off-peak sales. Annual increases resulting from total production meeting off-peak as well as general requirements would be modified as follows:

1963	29.4 percent
1964	0
1965	13.6
1966	44.0
1967	16.7
1968	19.0
1969	20.0
1970	16.7
1971	14.3

By 1980, the growth rate may still be around 10 percent, but will taper off significantly after that year. These higher rates in the earlier years have to be maintained if the objectives of the successive five-year plans are to be approached or reached.

Losses. Actual losses for the Interconnected System (Addis Ababa Complex) from 1957 through 1961 have been reported as follows[1] and as further indicated in Table VII-35.

Year	Millions of kw.-hr.			Percent Losses
	Production	Sales	Losses	
1957	35.5	25.3	10.2	29
1958	39.1	27.5	11.6	30
1959	45.0	33.5	11.5	34
1960	51.6	41.0	10.6	21
1961	60.3	50.2	10.1	17*

* Year of interconnection to Koka. Includes some transmission losses.

1/ Source, EELPA, January 1962 Report.

242

TABLE VII-35 - ENERGY AND DEMAND AT LOAD CENTER--ADDIS ABABA COMPLEX (CASES A AND B)

Year	Millions of kw.-hr. at high-voltage side of receiving-end substation			Per-cent annual load factor	Peak demand (kw.) at load	Peak demand kw. (rounded) at load
	Customer loads	Losses	Total			
1957	25.3	10.2	35.5	50	8,105	8,100
1958	27.5	11.6	39.1	51	8,752	8,800
1959	33.5	11.5	45.0	51.4	10,000	10,000
1960	41.0	10.6	51.6	53.8	10,949	11,000
1961	50.2	8.5	58.7	51.0	13,139	13,100
1962	75.0	7.9	82.9	53.8	17,591	17,600
1963	95.0	12.2	107.2	54.6	22,413	22,400
1964	95.0	12.2	107.2	54.6	22,413	22,400
1965	110.0	11.8	121.8	54.9	25,326	25,300
1966	155.0	20.5	175.5	58.7	34,130	34,100
1967	185.0	20.0	205.0	57.1	40,984	41,000
1968	220.0	23.7	243.7	57.1	48,721	49,000
1969	260.0	32.3	292.3	57.1	58,437	58,400
1970	305.0	36.3	341.3	57.1	68,233	68,200
1971	350.0	40.0	390.0	57.1	77,969	78,000
1972	399.0	45.6	444.6	57	89,041	89,000
1973	450.0	54.4	504.4	57	101,017	101,000
1974	513.0	58.4	571.4	58	112,462	112,500
1975	578.0	65.6	643.6	58	126,673	126,700
1976	648.0	73.6	721.6	58	142,025	142,000
1977	726.0	83.2	809.2	58	159,266	159,300
1978	807.0	92.0	899.0	58	176,940	177,000
1979	894.0	101.6	995.6	59	192,632	192,700
1980	985.0	112.0	1,097.0	59	212,251	212,300

243

Estimated losses for the same system through 1971 were as follows. 1/

1962	12 percent
1963	14
1964	14
1965	12
1966	14
1967	12
1968	12
1969	13
1970	13
1971	13

It should be understood that loss figures include meter errors and some system usage.

Losses for the isolated systems, which will be interconnected with the Addis Ababa Complex in the late 1970's as assumed for Case B in this study, will be somewhat higher; but, since the percent of the total production serving these added loads will be very small in comparison with the Addis Ababa Complex itself, the effect upon total system losses will be small. Tables VII-36, VII-37, VII-38, VII-39, and VII-40 show those losses.

Energy and Demand at Load Centers

Addis Ababa Complex. The energy and demand for the Addis Ababa Complex (Interconnected System) as seen from the 161-kv. side of a proposed substation near Addis Ababa are shown by Table VII-35, which indicates loads, losses, annual load factors, and peak demand. This is true for both Cases A and B.

Table VII-41 shows the breakdown of sales by the two major classes used. This applies to Case A only. Table VII-42 indicates the peak demand at load and at the powerplant for Case A only.

1/ Source, EELPA, January 1962 Report. (Includes transmission losses, whereas Table VII-35 does not.)

244

Agere Hiywet (Ambo), Case B only. Table VII-36 indicates the conditions at load, historical through 1960 and projected after that date. Total customer loads distributed by classes are shown on Table VII-43.

For this particular study, the connection of this isolated load to the Interconnected System was assumed to occur at the end of 1973.

Lekkemt (Case B only). Table VII-37 shows anticipated conditions beginning in 1963 through 1980 with Lekkemt being served by its own isolated diesel-electric system until connection with the Interconnected System is made in 1974. Total customer loads distributed by classes were estimated as shown on Table VII-44.

Jima (Case B only). Historial data through 1961 are shown on Table VII-38 with load forecasts from 1961 through 1980. As indicated in a prior section, Jima is served by its own isolated system, consisting of both hydro and diesel. Connection to the Interconnected System was assumed to occur in 1974. As is the situation with some of the other isolated systems, other facilities, such as larger hydroelectric systems, can be installed to serve an isolated system initially but can be connected later with the main Interconnected System when it expands. This possibility exists at Jima, where a larger plant on the Great Gibe River could be installed to carry the Jima load until interconnection was accomplished. Whether this is done or not is immaterial insofar as this particular study is concerned, except that when interconnection is made, all load is assumed to be carried by the Interconnected System with diesel sets moved elsewhere and the hydroelectric installations maintained for reserve or emergency use.

Total customer loads distributed by classes were as shown on Table VII-45.

Dessie (Case B only). Historical data from 1957 through 1960 are indicated with the projections going to 1980. Table VII-39 shows customer loads, losses, load factor, and peak demand by years for this load center with the tie to the Interconnected System occurring in 1977. Sales by classes of energy are as indicated in Table VII-46.

South Eritrea (Assab), Case B only. The EELPA acquired the existing electric supply and distribution facilities from a private operator in 1962, and EELPA forecasts the production and

245

TABLE VII-36 - ENERGY AND DEMAND AT LOAD CENTER--
AGERE HIYWET (AMBO), CASE B

Year	Thousands of kw.-hr. at high-voltage side of receiving-end substation: Customer loads	Load center losses	Load center total	Per-cent annual load factor	Peak demand (kw.) at load	Remarks
1957	137	64	201	30	76	Isolated System
1958	161	87	248	35	81	
1959	212	95	307	43	82	
1960	242	65	307	35	100	
1961	312	55	367	37	113	
1962	367	70	437	38	131	
1963	432	88	520	39	152	
1964	509	104	613	41	171	
1965	605	123	723	43	192	
1966	702	143	845	44	219	
1967	820	168	988	45	251	
1968	959	197	1,156	45	293	
1969	1,123	230	1,353	45	343	
1970	1,314	269	1,583	45	402	
1971	1,497	307	1,804	45	458	
1972	1,707	350	2,057	45	522	
1973	1,941	398	2,339	46	580	Inter-connect
1974	2,198	383	2,581	46	641	Inter-connected System
1975	2,477	432	2,909	47	707	
1976	2,779	485	3,264	47	793	
1977	3,251	568	3,819	47	928	
1978	3,641	636	4,277	47	1,039	
1979	4,030	704	4,734	48	1,126	
1980	4,441	776	5,217	48	1,241	

TABLE VII-37 - ENERGY AND DEMAND AT LOAD CENTER--
LEKKEMT (CASE B)

Year	Thousands of kw.-hr. at high-voltage side of receiving-end substation: Customer loads	Load center losses	Load center total	Per-cent annual load factor	Peak demand (kw.) at load	Remarks
1962	280	70	350	25	160	
1963	454	106	560	30	213	
1964	781	171	952	35	311	
1965	1,264	259	1,522	36	483	
1966	1,897	388	2,285	37	705	
1967	2,655	544	3,199	38	961	
1968	3,586	734	4,320	39	1,264	
1969	4,661	955	5,616	40	1,603	Isolated System
1970	6,059	1,241	7,300	40	2,083	
1971	7,574	1,551	9,125	41	2,541	
1972	9,088	1,862	10,950	41	3,049	
1973	10,907	2,233	13,140	42	3,571	Inter-
1974	12,979	2,267	15,246	43	4,047	connect
1975	14,879	2,599	17,378	43	4,613	
1976	17,408	3,041	20,449	43	5,429	
1977	20,192	3,528	23,720	43	6,197	
1978	23,473	4,091	27,514	43	7,304	Inter-connected System
1979	26,936	4,705	31,641	43	8,400	
1980	30,707	5,364	36,071	44	9,358	

TABLE VII-38 - ENERGY AND DEMAND AT LOAD CENTER--
JIMA (CASE B)

Year	Thousands of kw.-hr. at high-voltage side of receiving-end substation: Customer loads	Load center losses	Load center total	Per-cent annual load factor	Peak demand (kw.) at load	Remarks
1957	325	153	478	25	218	
1958	358	192	550	25	251	
1959	412	185	597	44	155	
1960	643	271	914	34	306	
1961	1,167	206	1,373	29	540	Isolated System
1962	1,517	267	1,784	32	636	
1963	1,896	334	2,230	34	749	
1964	2,351	414	2,765	36	877	
1965	2,891	510	3,401	38	1,022	
1966	3,527	622	4,149	40	1,184	
1967	4,267	753	5,020	42	1,364	
1968	5,121	903	6,024	45	1,528	
1969	6,093	1,075	7,168	45	1,818	
1970	7,190	1,268	8,458	45	2,145	
1971	8,412	1,484	9,896	45	2,510	
1972	9,943	1,707	11,650	45	2,955	
1973	10,930	1,929	12,859	46	3,191	Inter-connect
1974	12,132	1,784	13,916	46	3,453	
1975	13,224	1,945	15,169	46	3,764	
1976	14,293	2,092	16,385	46	4,066	Inter-connected System
1977	15,425	2,268	17,693	46	4,391	
1978	16,505	2,427	18,932	47	4,598	
1979	17,660	2,597	20,257	47	4,920	
1980	18,896	2,778	21,674	47	5,264	

248

TABLE VII-39 - ENERGY AND DEMAND AT LOAD CENTER--
DESSIE (CASE B)

Year	Thousands of kw.-hr. at high-voltage side of receiving-end substation: Customer loads	Load center losses	Load center total	Per-cent annual load factor	Peak demand (kw.) at load	Remarks
1957	161	76	237	25	108	Isolated System
1958	166	89	255	25	116	
1959	206	93	299	41	83	
1960	370	98	468	22	243	
1961	762	134	896	26	393	
1962	1,487	305	1,792	30	682	
1963	2,603	533	3,136	33	1,085	
1964	4,165	853	5,018	35	1,637	
1965	5,831	1,194	7,025	37	2,167	
1966	7,580	1,553	9,133	40	2,606	
1967	9,400	1,925	11,325	43	3,007	
1968	11,656	2,387	14,043	44	3,643	
1969	13,986	2,865	16,851	45	4,275	
1970	16,783	3,438	20,221	46	5,018	
1971	20,140	4,125	24,265	46	6,022	
1972	23,967	4,908	28,875	46	7,166	
1973	28,520	5,841	34,361	46	8,527	
1974	33,652	6,893	40,545	46	10,062	
1975	39,710	8,133	47,843	46	11,873	
1976	46,460	9,516	55,976	46	13,891	Inter-connect
1977	54,359	9,496	63,855	47	15,509	Inter-connected System
1978	63,056	11,016	74,072	47	17,991	
1979	73,145	12,779	85,924	47	20,870	
1980	84,117	14,695	98,812	47	24,000	

249

TABLE VII-40 - ENERGY AND DEMAND AT LOAD CENTER--
SOUTH ERITREA (CASE B)

Year	Thousands of kw.-hr. at high-voltage side of receiving-end substation			Per-cent annual load factor	Peak demand (kw.) at load	Remarks
	Customer loads	Load center losses	Load center total			
1959	1,200	500	1,700	33	588	Isolated System
1960	1,380	460	1,840	40	525	
1961	1,500	480	1,980	45	502	
1962	1,700	430	2,130	52	468	
1963	2,410	570	2,980	59	577	
1964	3,130	740	3,870	60	736	
1965	4,050	950	5,000	55	1,038	
1966	5,260	1,240	6,500	50	1,484	
1967	6,850	1,600	8,450	48	2,009	
1968	15,250	3,350	18,600	65	3,267	
1969	22,900	4,200	27,100	65	4,759	
1970	22,940	5,040	27,980	64	4,991	
1971	30,340	6,660	37,000	65	6,498	
1972	38,540	8,460	47,000	65	8,254	
1973	46,030	9,430	55,460	64	9,892	
1974	53,400	10,930	64,330	62	11,845	
1975	61,930	12,690	74,620	60	14,197	
1976	72,080	13,730	85,810	59	16,603	Inter-connect
1977	82,890	13,330	96,220	58	18,938	Inter-connected System
1978	96,600	15,530	112,130	60	21,333	
1979	102,480	16,470	118,950	62	21,901	
1980	114,780	18,450	133,230	62	24,530	

250

TABLE VII-41 - SALES BY CLASSES--ADDIS ABABA COMPLEX (CASE A)

Year	In millions of kw.-hr.		
	National economy	Public consumption	Total
1957	10.3	15.0	25.3
1958	11.5	16.0	27.5
1959	14.4	19.1	33.5
1960	18.0	23.0	41.0
1961	22.6	27.6	50.2
1962	34.0	41.0	75.0
1963	43.5	51.5	95.0
1964	43.9	51.1	95.0
1965	51.3	58.7	110.0
1966	72.8	82.2	155.0
1967	87.7	97.3	185.0
1968	105.1	114.9	220.0
1969	125.3	134.7	260.0
1970	148.2	156.8	305.0
1971	171.5	178.5	350.0
1972	197.1	201.9	399.0
1973	224.1	225.9	450.0
1974	257.5	255.5	513.0
1975	292.5	285.5	578.0
1976	330.0	318.0	648.0
1977	373.0	353.0	726.0
1978	418.0	389.0	807.0
1979	467.0	427.0	894.0
1980	518.0	467.0	985.0

TABLE VII-42 - ESTIMATED PEAK DEMAND--INTERCONNECTED SYSTEM, ADDIS ABABA COMPLEX (CASE A)

Year	Peak demand at load (kw.)	Transmission losses at peak demand (kw)	Peak demand at powerplant (kw.)	Peak demand at powerplant kw. (rounded)
1961	13,139	731	13,870	13,900
1962	17,591	959	18,550	18,600
1963	22,413	1,279	23,692	23,700
1964	22,413	1,279	23,692	23,700
1965	25,326	1,462	26,788	26,800
1966	34,130	2,055	36,185	36,200
1967	40,984	2,283	43,267	43,300
1968	48,721	2,877	51,598	51,600
1969	58,437	3,516	61,953	62,000
1970	68,233	3,973	72,206	72,200
1971	77,969	4,566	82,535	82,600
1972	89,041	5,205	94,246	94,300
1973	101,017	6,210	107,227	107,300
1974	112,462	6,667	119,129	119,100
1975	126,673	7,466	134,139	134,100
1976	142,025	8,400	150,425	150,400
1977	159,266	9,500	168,766	169,000
1978	176,940	10,500	187,440	187,500
1979	192,632	11,600	204,232	204,000
1980	212,251	12,785	225,036	225,000
1981	232,799	14,155	246,954	247,000

252

TABLE VII-43 - SALES BY CLASSES--AGERE HIYWET (AMBO), CASE B

Year	In thousands of kw.-hr.		
	National economy	Total consumption	Total
1957	34	103	137
1958	40	121	161
1959	53	159	212
1960	62	180	242
1961	82	230	312
1962	98	269	367
1963	118	314	432
1964	143	366	509
1965	172	428	600
1966	205	497	702
1967	244	576	820
1968	292	667	959
1969	348	775	1,123
1970	415	899	1,314
1971	482	1,015	1,497
1972	559	1,148	1,707
1973	648	1,293	1,941
1974	747	1,451	2,198
1975	857	1,620	2,477
1976	978	1,801	2,779
1977	1,163	2,088	3,251
1978	1,325	2,316	3,641
1979	1,491	2,539	4,030
1980	1,670	2,771	4,441

TABLE VII-44 - SALES BY CLASSES--LEKKEMT
(CASE B)

Year	In thousands of kw.-hr.		
	National economy	Public consumption	Total
1963	114	340	454
1964	198	583	781
1965	326	938	1,264
1966	497	1,400	1,897
1967	706	1,949	2,655
1968	968	2,618	3,586
1969	1,277	3,384	4,661
1970	1,684	4,373	6,059
1971	2,136	5,438	7,574
1972	2,599	6,489	9,088
1973	3,163	7,744	10,907
1974	3,816	9,163	12,979
1975	4,434	10,445	14,879
1976	5,257	12,151	17,408
1977	6,063	13,752	19,815
1978	7,261	16,162	23,423
1979	8,458	18,478	26,936
1980	9,765	20,819	30,707

254

TABLE VII-45 - SALES BY CLASSES--JIMA (CASE B)

Year	In thousands of kw.-hr.		
	National economy	Public consumption	Total
1957	81	244	325
1958	89	269	358
1959	103	309	412
1960	161	482	643
1961	296	1,463	1,167
1962	391	1,126	1,517
1963	497	1,399	1,896
196	625	1,726	2,351
1965	780	2,111	2,891
1966	966	2,561	3,527
1967	1,186	3,081	4,267
1968	1,444	3,677	5,121
1969	1,742	4,351	6,093
1970	2,085	5,105	7,190
1971	2,473	5,939	8,412
1972	2,963	6,980	9,943
1973	3,300	7,630	10,930
1974	3,712	8,420	12,132
1975	4,099	9,125	13,224
1976	4,488	9,805	14,293
1977	4,095	10,520	15,425
1978	5,315	11,190	16,505
1979	5,757	11,903	17,660
1980	6,235	12,661	18,896

TABLE VII-46 - SALES BY CLASSES--DESSIE (CASE B)

Year	In thousands of kw.-hr.		
	National economy	Public consumption	Total
1957	40	121	161
1958	41	125	166
1959	52	154	206
1960	92	278	370
1961	194	568	762
1962	384	1,103	1,487
1963	682	1,921	2,603
1964	1,108	3,057	4,165
1965	1,574	4,257	5,831
1966	2,077	5,503	7,580
1967	2,613	6,787	9,400
1968	3,287	8,369	11,656
1969	4,000	9,986	13,986
1970	4,867	11,916	16,783
1971	5,921	14,219	20,140
1972	7,142	16,825	23,967
1973	8,613	19,907	28,520
1974	10,298	23,354	33,652
1975	12,310	27,400	39,710
1976	14,588	31,872	46,460
1977	17,286	37,073	54,359
1978	20,304	42,752	63,056
1979	23,845	49,300	73,145
1980	27,759	56,358	84,117

sales as follows through 1971, using an increase of 30 percent for five years and 20 percent for the last five.

Year	Thousands of kw.-hr.		
	Sales	Losses	Production
1962	5,000	1,000	6,000
1963	7,500	1,500	9,000
1964	9,500	1,500	11,000
1965	12,000	2,000	14,000
1966	16,000	4,000	20,000
1967	21,000	4,000	25,000
1968	26,000	5,000	31,000
1969	32,000	5,000	37,000
1970	39,000	5,000	44,000
1971	47,000	6,000	53,000

Studies using Table VII-40 were prepared prior to the availability of this information; and, although in general it uses about the same rate of initial growth, the base loads for 1959-1961 are considerably lower. However, both estimates would approach about the same values at the assumed date of connection in 1977 to the Interconnected System, so there is no appreciable effect upon the objective of this particular study.

Sales by classes of energy are as shown on Table VII-47.

Summary

Tables VII-35, VII-41, and VII-48 summarize the estimated future requirements by showing the peak demand at load centers, diversity factor, peak demand of the interconnected load, transmission losses at peak demand, and the peak demand at the Finchaa Sub-Basin powerplants. (Tables VII-35 and VII-41 indicate conditions for Case A, and Table VII-48 for Case B.)

Estimated Future Need for Additional Generator Capacity--1964-1967

Table VII-30 gives the firm kilowatt capacity of the existing Interconnected System (Addis Ababa Complex) as 30,000 kw., including the Alemaya diesel but not the Addis Ababa steam plant. Keeping Alemaya (2,000 kw.) in reserve (because of its higher operating cost) leaves 28,000 kw. of firm capacity.

TABLE VII-47 - SALES BY CLASSES--SOUTH ERITREA (CASE B)

Year	In thousands of kw.-hr.		
	National economy	Public consumption	Total
1962	1,190	510	1,700
1963	1,570	840	2,410
1964	1,880	1,250	3,130
1965	2,030	2,020	4,050
1966	2,100	3,160	5,260
1967	2,400	4,450	6,850
1968	10,680	4,570	15,250
1969	16,030	6,870	22,900
1970	15,600	7,360	22,940
1971	21,240	9,100	30,340
1972	26,980	11,560	38,540
1973	31,300	14,730	46,030
1974	35,240	18,160	53,400
1975	37,160	24,770	61,930
1976	41,810	30,270	72,080
1977	45,590	37,300	82,890
1978	57,960	38,640	96,600
1979	63,170	39,310	102,480
1980	72,310	42,470	114,780

TABLE VII-48 - ESTIMATED PEAK DEMAND--INTERCONNECTED SYSTEM (CASE B)

Year	Kilowatts											
	Peak Demand at Load Centers							Diversity factor	Peak demand of interconnected load	Transmission losses at peak demand	Peak demand at power-plant	Peak demand at power-plant (rounded)
	Addis Ababa	Agere Hiywet (Ambo)	Lekkemt	Jima	Dessie	South Eritrea (Assab)	Sum					
1957	8,105						8,105		8,105			
1958	8,752						8,752		8,752			
1959	10,000						10,000		10,000			
1960	10,949						10,949		10,949			
1961	13,139						13,139		13,139	731	13,870	13,900
1962	17,591						17,591		17,591	959	18,550	18,600
1963	22,413						22,413		22,413	1,279	23,692	23,700
1964	22,413						22,413		22,413	1,279	23,692	23,700
1965	25,326						25,326		25,326	1,462	26,788	26,800
1966	34,130						34,130		34,130	2,055	36,185	36,200
1967	40,984						40,984		40,984	2,283	43,267	43,300
1968	48,721						48,721		48,721	2,877	51,598	51,600
1969	58,437						58,437		58,437	3,516	61,953	62,000
1970	68,233						68,233		68,233	3,973	72,206	72,200
1971	77,969						77,969		77,969	4,566	82,535	82,600
1972	89,041						89,041		89,041	5,205	94,246	94,300
1973	101,017						101,017		101,017	6,210	107,227	107,300
1974	112,462	641	4,047	3,453			120,603	1.05	114,860	6,704	121,564	121,600
1975	126,673	707	4,613	3,764			135,757	1.06	128,073	7,529	135,601	135,600
1976	142,025	793	5,429	4,066			152,313	1.06	143,692	8,447	152,139	152,100
1977	159,266	928	6,197	4,391	15,509	18,938	205,229	1.15	179,460	10,346	188,806	188,800
1978	176,940	1,039	7,304	4,598	17,991	21,333	229,205	1.15	199,309	11,542	210,851	210,900
1979	192,632	1,126	8,400	4,920	20,870	21,901	249,849	1.15	217,260	12,747	230,007	230,000
1980	212,251	1,241	9,358	5,264	24,000	24,530	276,644	1.15	240,560	13,995	254,555	255,000

There are several industrial plants generating for their own use, and the annual generated energy is indicated on Drawing No. 4.0-BN-148. These plants are not operated so as to contribute any support to the Interconnected System, and percentagewise they will ultimately represent only a small part of the total energy generated.

Table VII-49 gives an indication of the adequacy of the present power supply through 1967.

TABLE VII-49 - DEPENDABLE SYSTEM CAPACITY TO MEET PEAK DEMAND VERSUS SYSTEM COINCIDENTAL PEAK DEMAND AT PLANT--1964-1967 (CASE A OR B)

	Kilowatts		
Year	Dependable system capacity	System coincidental peak demand	Surplus (+) or deficit (-)
1964	28,000	23,700	+4,300
1965	28,000	26,800	+1,200
1966	28,000	36,200	-8,200
1967	28,000	43,300	-15,300

By the end of 1965, only a small surplus capacity will exist (1,200 kw.) using the three dependable low cost hydro sources. However, if the Addis Ababa steam plant and the Alemaya diesel were used, an additional 7,000 kw. of dependable capacity would become available, changing the 1965 surplus of 1,200 kw. to a surplus of 8,200 kw. and the 1966 deficit of 8,200 kw. to a deficit of 1,200 kw. Therefore, even with all available resources in operation, new generation will be required by the end of 1965.

Power Facilities Planned or Under Consideration--1964-1967

The EELPA is planning the construction of two medium-head hydroelectric developments of 37 mw. each, known as Awash No. 2 and Awash No. 3. (The first development on the Awash River was Koka.) These two will be located on the Awash River about 120 km. southeast of Addis Ababa. The main water regulation will be supplied by the Koka reservoir, but smaller dams will be necessary at each plant for sufficient forebay storage to provide minimum regulation to meet

the hourly load curve. In addition to the dam and the required intake structure for the power facilities, each installation will have a five-meter pressure tunnel, surge tank, valve chamber, two penstocks of three-meter diameter, a powerhouse for two Francis turbines with necessary service facilities, and an open-air switch yard. The effective head of each development is to be approximately 60 meters, and the distance between the intake and the powerhouse will be 2,000 meters for Awash No. 2 and 900 meters for Awash No. 3. Designs have been completed, and it appears that construction of Awash No. 2 will start in early 1964, with two years to complete. Construction of Awash No. 3 will follow immediately. On this basis, Awash No. 2 may be energized at the end of 1965 and Awash No. 3 by the end of 1967.

Estimated Future Deficiency in Power Supply--1968-1980

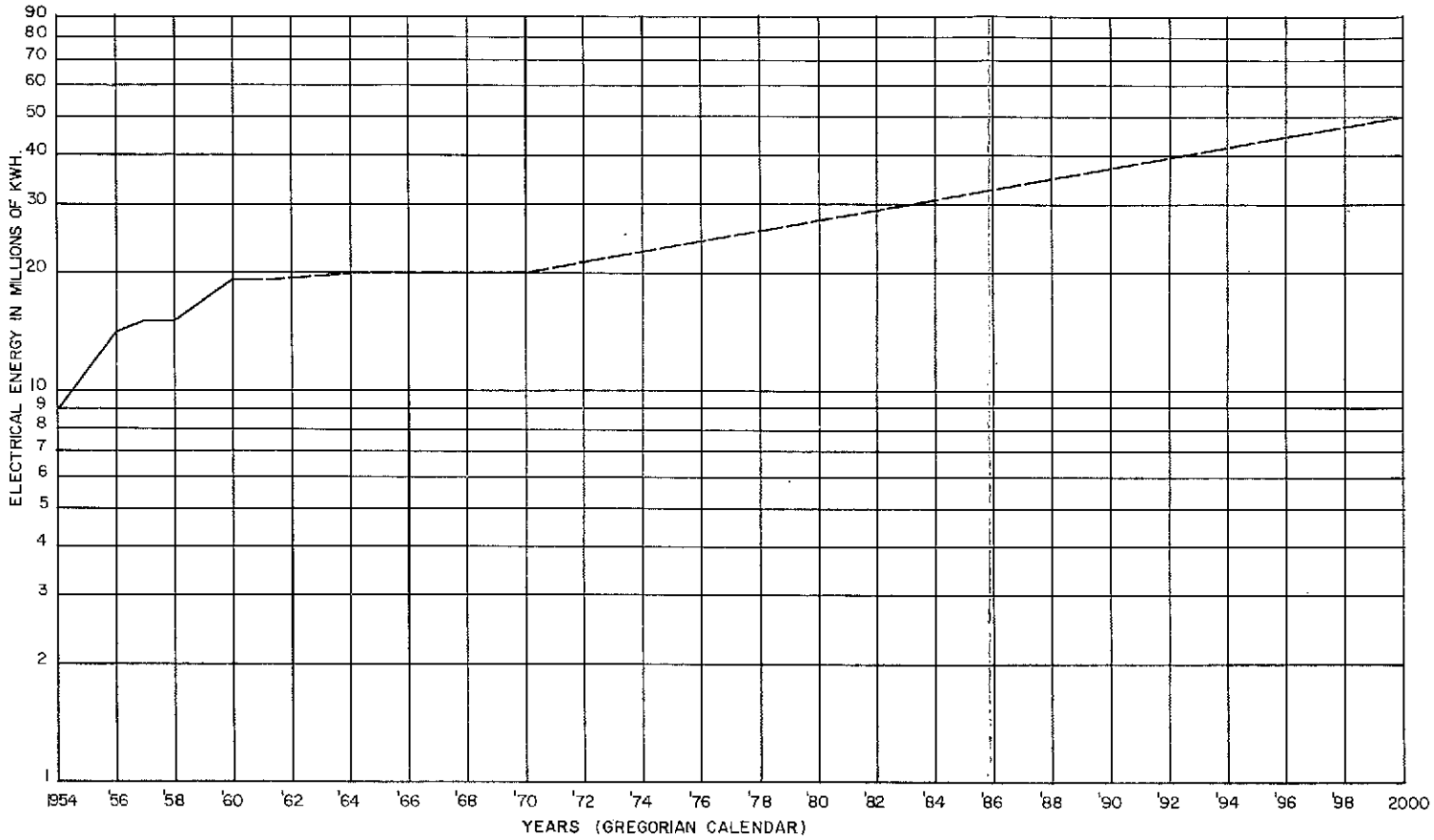
If the objectives of the second and subsequent five-year development plans for the Empire are to be approached or reached, wherein the present agricultural economy is to be successfully transformed into an agricultural-industrial one by 1982, the need for energy to meet industrial as well as residential and commercial requirements will be substantial.

Table VII-49 indicates that the first deficiency in system capability would occur in 1966, meaning that additional generating capacity would be required by the end of 1965. By that time, Awash No. 2 would be placed in operation, followed by Awash No. 3 at the end of 1967. Considering the capability of these installations, Tables VII-50 and VII-51 summarize the anticipated system conditions anticipated through 1980 for Cases A and B, respectively.

Under both Cases A and B, new generating facilities should go on the line in 1974 so as to insure adequate capability for load and reserves. This presupposes that the fourth and last Awash plant would have been placed in operation in 1971.

Finchaa Sub-Basin as a Source in Meeting Future Deficiencies in Power Supply

As described in a previous section, the Finchaa Sub-Basin has two, high-head, hydroelectric powerplant possibilities--one on the Finchaa River and the other on the Neshe River. Each has the capability of meeting a peak demand of about 80 mw. during an adverse water year. They are located within 30 kilometers airline distance of each other. The most economical power will come from the Finchaa powerplant, and it probably would be developed first.



ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH U.S. DEPT. OF ST., A.I.D. U.S. DEPT. OF INT., BUR. OF RECL.

DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS

BLUE NILE RIVER BASIN

ELECTRIC POWER LOAD ANALYSIS

PRODUCTION OF ELECTRICITY BY INDUSTRIAL FIRMS

DRAWN C.L. CURTIS
TRACED A.N. MUSSA
CHECKED C.L.C. - G.V.J.
SUBMITTED C.L.C.
RECOMMENDED P.W.K.
APPROVED C.E.B.

Addis Ababa Ethiopia Apr 30, 1963

40-BN-148

TABLE VII-50 - DEPENDABLE SYSTEM CAPACITY TO MEET PEAK DEMAND VERSUS SYSTEM COINCIDENTAL PEAK DEMAND AT PLANT--1968-1980 (CASE A)

Year	Dependable system capacity (kw.)	System coincidental peak demand (kw.)	Surplus (+) or deficit (-) (kw.)	Remarks
1966	65,000	36,200	+28,800	37-mw. Awash No. 2 added
1967	65,000	43,300	+21,700	
1968	102,000	51,600	+50,400	37-mw. Awash No. 3 added
1969	102,000	62,000	+40,000	
1970	102,000	72,200	+29,800	
1971	139,000	82,600	+56,400	37-mw. Awash No. 4 added
1972	139,000	94,300	+44,700	
1973	139,000	107,300	+31,700	
1974	139,000	119,100	+19,900	
1975	139,000	134,100	+4,900	
1976	139,000	150,400	-11,400	
1977	139,000	169,000	-30,000	
1978	139,000	187,500	-48,500	
1979	139,000	204,000	-65,000	
1980	139,000	225,000	-86,000	
1981	139,000	247,000	-108,000	

263

TABLE VII-51 - DEPENDABLE SYSTEM CAPACITY TO MEET PEAK DEMAND VERSUS SYSTEM COINCIDENTAL PEAK DEMAND AT PLANT--1968-1980 (CASE B)

Year	Dependable system capacity (kw.)	System coincidental peak demand (kw.)	Surplus (+) or deficit (-) (kw.)	
1966	65,000	36,200	+28,800	37-mw. Awash No. 2 added
1967	65,000	43,300	+21,700	
1968	102,000	51,600	+50,400	37-mw. Awash No. 3 added
1969	102,000	62,000	+40,000	
1970	102,000	72,800	+29,800	
1971	139,000	82,600	+56,400	37-mw. Awash No. 4 added
1972	139,000	94,300	+44,700	
1973	139,000	107,300	+31,700	
1974	139,000	121,600	+17,400	
1975	139,000	135,600	+3,400	
1976	139,000	152,100	-13,100	
1977	139,000	188,800	-49,800	
1978	139,000	210,900	-71,900	
1979	139,000	230,000	-91,000	
1980	139,000	255,000	-116,000	

The Awash River has advantages in that it is generally closer to the principal load centers, but the development of the three or four hydroelectric installations there will depend primarily upon the Koka reservoir for regulation. Whether Awash No. 4 is developed or not would depend somewhat upon the time that it would take to bring the Finchaa plant into production.

In this study, it is assumed that the Finchaa plant would not be brought into production during the year 1971. Assuming three years for construction, final construction would have to begin in 1968. Allowing at least two to three years for feasibility studies, another year for final design, and possibly a year at least for slippage, work would have to start immediately on the feasibility surveys and studies. While it might be possible to get Finchaa into production during 1971, the extra time allowed by constructing Awash No. 4 has been used.

It should be recognized that constructing four hydroelectric powerplants cascaded on one river (Awash), regulated by one reservoir and constituting 95 percent of the utility electrical energy source for the heart of the Empire, may not be the most desirable situation. This is especially true when one considers leakage problems associated with the one reservoir and the yet unknown consequences of reservoir sedimentation and evaporation at Koka. Therefore, every effort should be made to develop other hydroelectric facilities as soon as possible in another river basin conveniently located near Addis Ababa. The Finchaa Sub-Basin powerplants offer a good solution to the problem, and at the same time the other aspects of the multiple-purpose projects will be highly beneficial to the economy.

Therefore, if possible, consideration should be given to expediting preconstruction activities on the Finchaa Sub-Basin so that the Finchaa power facilities can be placed into operation when needed following Awash No. 3. However, this may not be possible and, as explained, Awash No. 4 may be required.

Future deficiencies in the power supply for both Cases A and B can be met by the Finchaa Sub-Basin powerplants, together with the four Awash plants, for some time into the future, perhaps to the year 1980 or 1981 even at an optimistic rate of load growth. This is illustrated by Tables VII-52 and VII-53 for Cases A and B, respectively. The Interconnected System, as it will appear (Case A or B) in 1971, is shown on Drawing No. 4.0-Et-14.

TABLE VII-52 - ESTIMATED FUTURE NEEDS FOR ADDITIONAL CAPACITY USING FINCHAA SUB-BASIN FACILITIES--1968-1980 (CASE A)

Year	Dependable system capacity (kw.)	System coincidental peak demand (kw.)	Surplus (+) or deficit (-) (kw.)	New generating facilities
1966	65,000	36,200	+28,800	37-mw. Awash No. 2 added
1967	65,000	43,300	+21,700	
1968	102,000	51,600	+50,400	37-mw. Awash No. 3 added
1969	102,000	62,000	+40,000	
1970	102,000	72,200	+29,800	
1971	139,000	82,600	+56,400	37-mw. Awash No. 4 added
1972	139,000	94,300	+44,700	
1973	139,000	107,300	+31,700	
1974	219,000	119,100	+99,900	80-mw. Finchaa added
1975	219,000	134,100	+84,900	
1976	219,000	150,400	+68,600	
1977	219,000	169,000	+50,000	
1978	299,000	187,500	+111,500	80-mw. Neshe added
1979	299,000	204,000	+95,000	
1980	299,000	225,000	+74,000	
1981	299,000	247,000	+52,000	

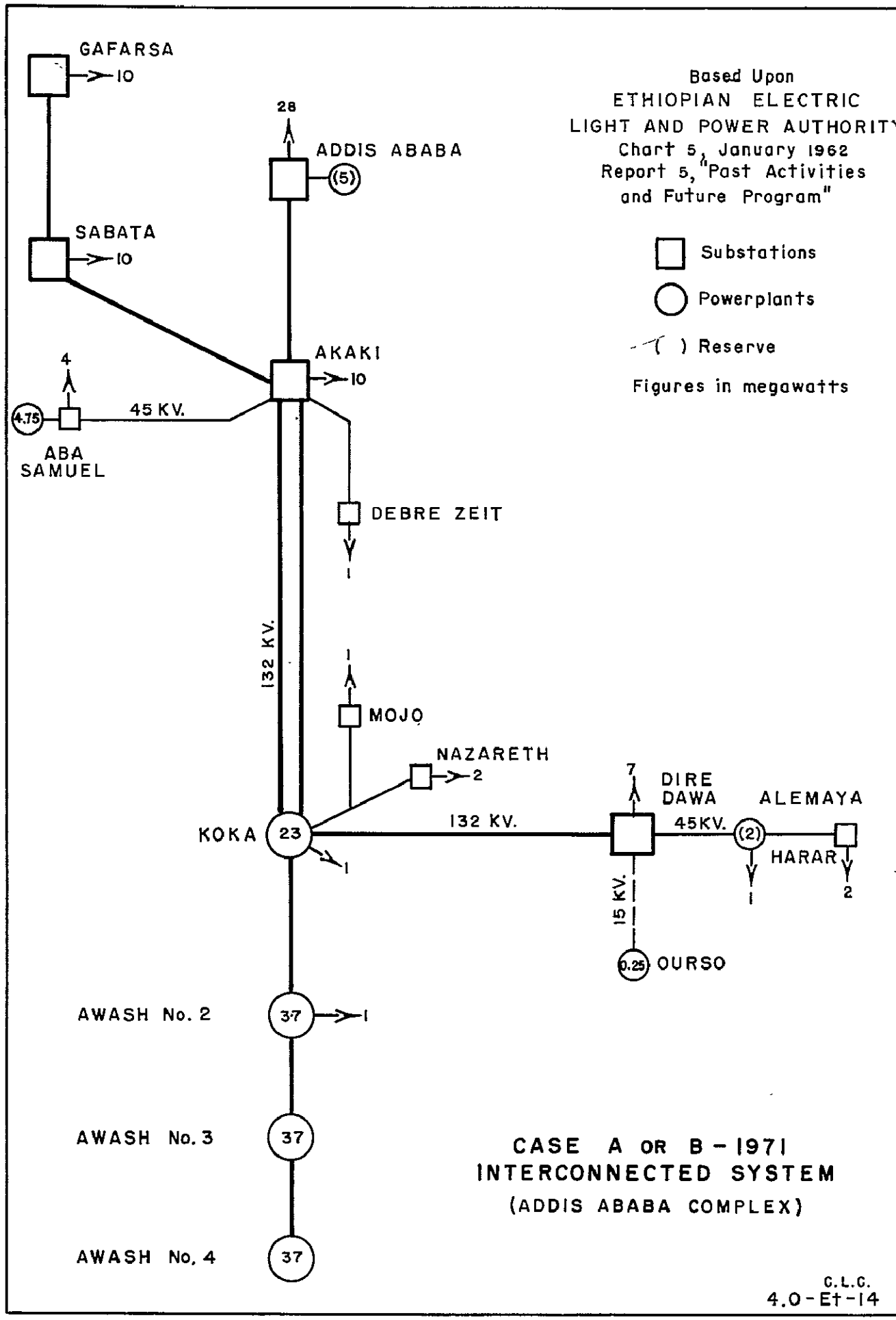
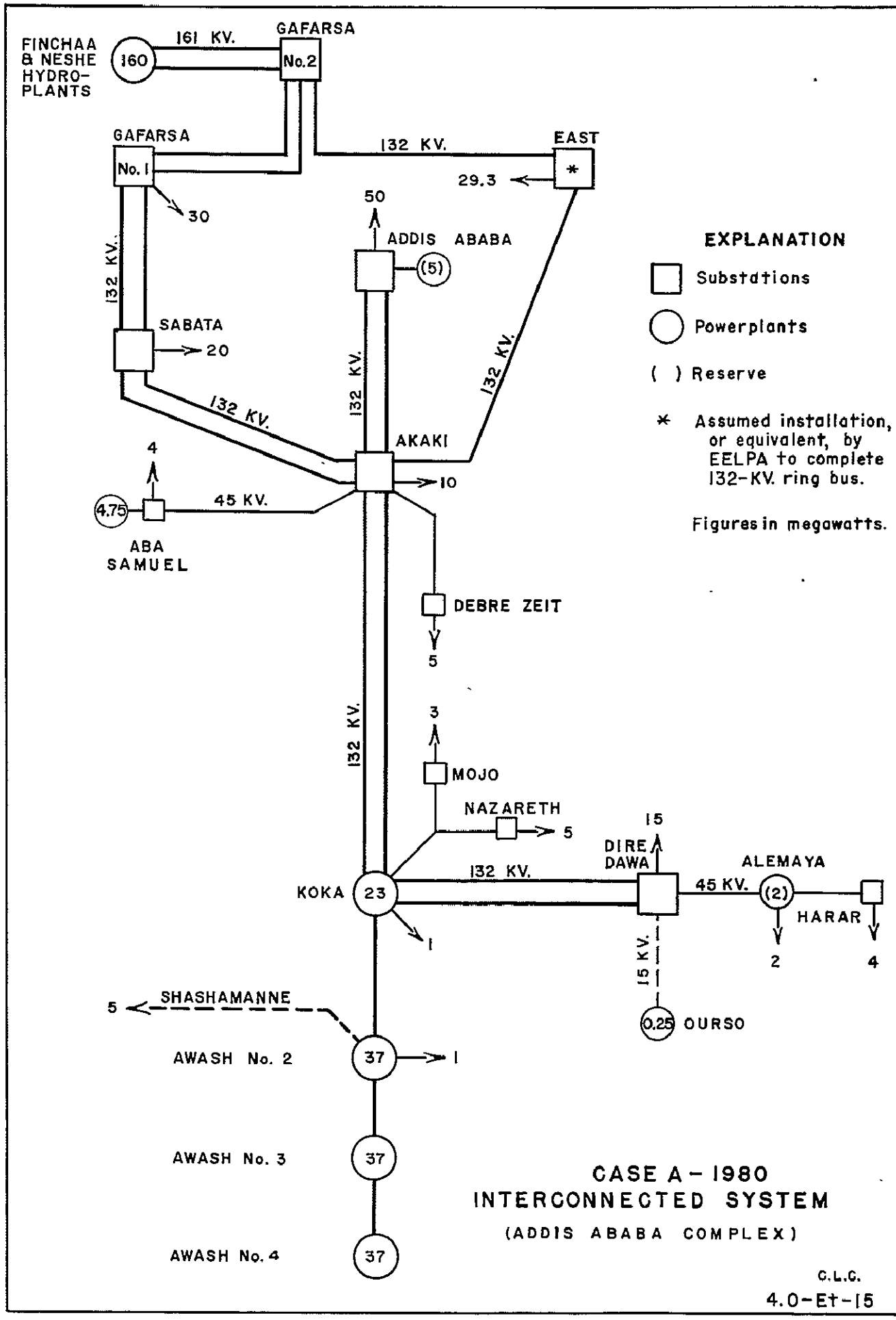
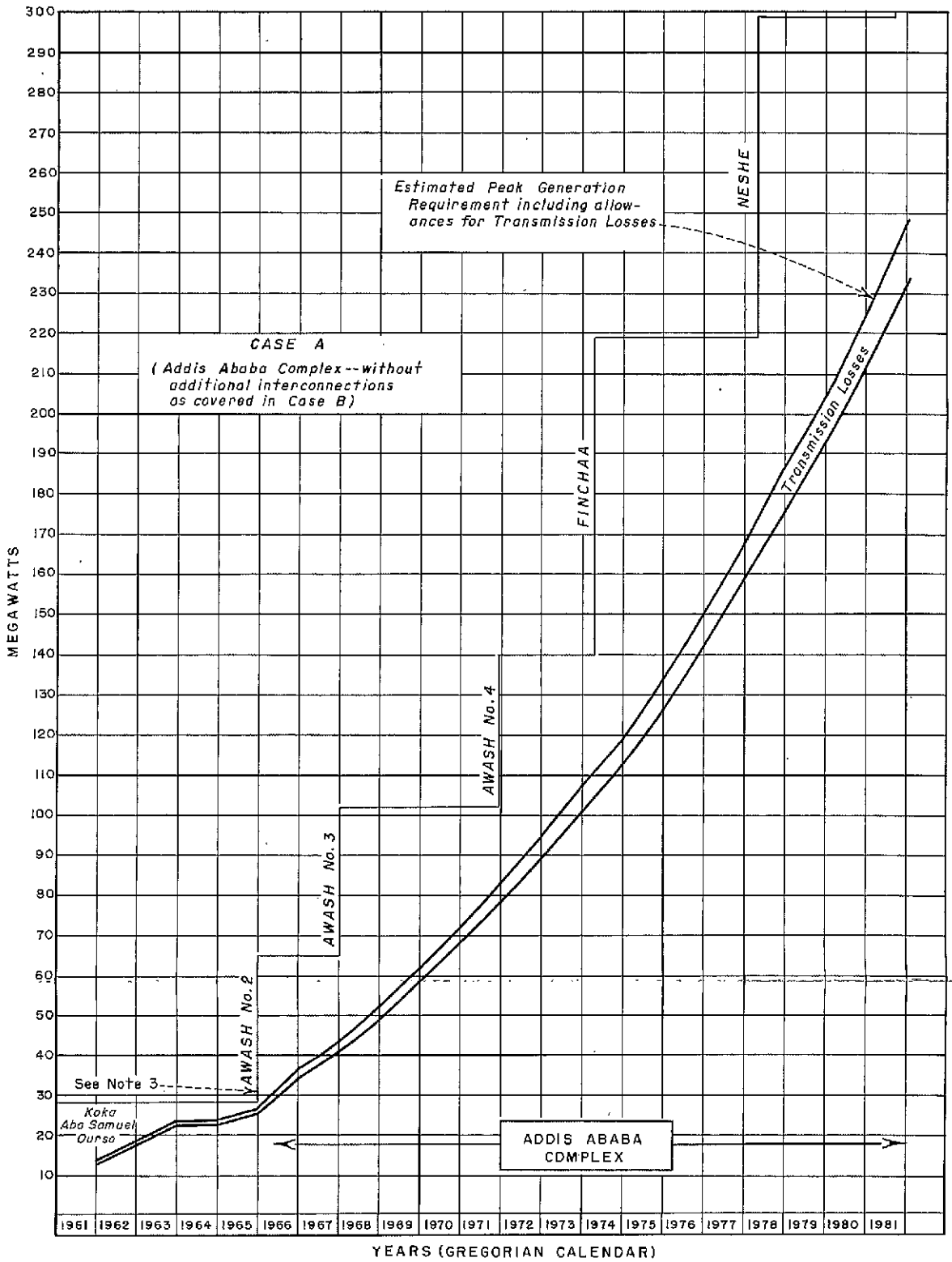

GAFARSA
10
28
ADDIS ABABA
(5)
SABATA
10
AKAKI
10
4
4.75
45 KV.
ABA SAMUEL
DEBRE ZEIT
1
132 KV.
1
MOJO
NAZARETH
2
7
DIRE DAWA
ALEMAYA
KOKA
23
132 KV.
45KV.
(2)
HARAR
1
1
2
15 KV.
0.25
OURSO
AWASH No. 2
37
1
AWASH No. 3
37
AWASH No. 4
37
Based Upon
ETHIOPIAN ELECTRIC
LIGHT AND POWER AUTHORITY
Chart 5, January 1962
Report 5, "Past Activities
and Future Program"
Substations
Powerplants
( ) Reserve
Figures in megawatts
CASE A OR B - 1971
INTERCONNECTED SYSTEM
(ADDIS ABABA COMPLEX)
C.L.C.
4.0-Et-14

TABLE VII-53 - ESTIMATED FUTURE NEEDS FOR ADDITIONAL CAPACITY USING FINCHAA SUB-BASIN FACILITIES--1968-1980 (CASE B)

Year	Dependable system capacity (kw.)	System coincidental peak demand (kw.)	Surplus (+) or deficit (-) (kw.)	New generating facilities
1966	65,000	36,200	+28,800	37-mw. Awash No. 2 added
1967	65,000	43,300	+21,700	
1968	102,000	51,600	+50,400	37-mw. Awash No. 3 added
1969	102,000	62,000	+40,000	
1970	102,000	72,200	+29,800	
1971	139,000	82,600	+56,400	37-mw. Awash No. 4 added
1972	139,000	94,300	+44,700	
1973	139,000	107,300	+31,700	
1974	219,000	121,600	+97,400	80-mw. Finchaa added
1975	219,000	135,600	+83,400	
1976	219,000	152,100	+66,900	
1977	219,000	188,800	+30,200	
1978	299,000	210,900	+88,100	80-mw. Neshe added
1979	299,000	230,000	+69,000	
1980	299,000	255,000	+44,000	

268


FINCHAA & NESHE HYDRO-PLANTS
160
161 KV.
GAFARSA No.2
GAFARSA No. 1
30
132 KV.
EAST *
29.3
50
ADDIS ABABA
(5)
132 KV.
SABATA
20
132 KV.
132 KV.
132 KV.
AKAKI
10
4
4.75
45 KV.
ABA SAMUEL
DEBRE ZEIT
5
132 KV.
3
MOJO
NAZARETH
5
15
DIRE DAWA
ALEMAYA
KOKA
23
132 KV.
45 KV.
(2)
HARAR
1
2
4
15 KV.
0.25
OURSO
5
SHASHAMANNE
AWASH No. 2
37
1
AWASH No. 3
37
AWASH No. 4
37
EXPLANATION
Substations
Powerplants
( ) Reserve
* Assumed installation, or equivalent, by EELPA to complete 132-KV. ring bus.
Figures in megawatts.
CASE A - 1980
INTERCONNECTED SYSTEM
(ADDIS ABABA COMPLEX)
C.L.C.
4.0-Et-15



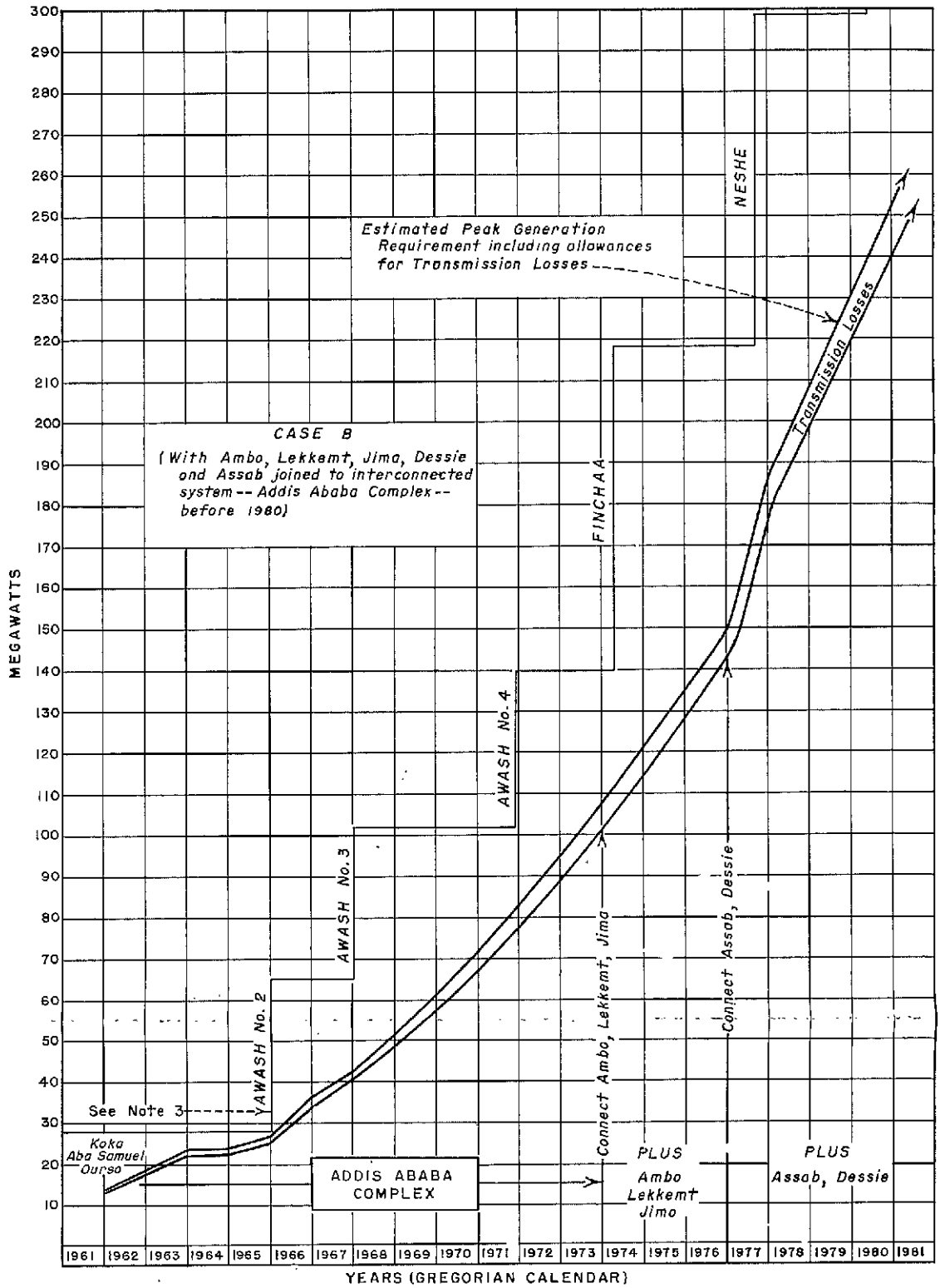
NOTES:

1. Designs completed in 1963 for Awash Powerplants No's. 2 and 3, with construction to start in early 1964.
2. One Megawatt = 1000 Kilowatts.
3. 7 mw thermal plus 11.5 mw from hydro (Koka 3rd Unit in adverse water year) available as reserves in addition to that included above.

BLUE NILE PROJECT
ESTIMATED PEAK GENERATION REQUIREMENTS AND SCHEDULE OF POWERPLANT INSTALLATIONS
CASE A
INTERCONNECTED SYSTEM

4.0-BN-172

C.L.C.



NOTES:

1. Designs completed in 1963 for Awash Powerplants Nos. 2 and 3 with construction to start in early 1964.
2. One Megawatt = 1000 Kilowatts.
3. 7 mw thermal plus 11.5 mw from hydro (Koka 3rd. Unit in adverse water year) available as reserve in addition to that included above.

BLUE NILE PROJECT
ESTIMATED PEAK GENERATION REQUIREMENTS AND SCHEDULE OF POWERPLANT INSTALLATIONS
CASE B
INTERCONNECTED SYSTEM

4.0-BN-173

C.L.C.

271

probable single-line diagram of the Interconnected System as it may exist in 1980, Case A only.

Estimated Power Costs of Alternative Sources

Direct power benefits as discussed in SECTION VIII can be measured by the lesser of two figures--the estimated cost of the most economical alternative source of equivalent power likely to be developed in the market area in the absence of either of the projects in the Finchaa Sub-Basin, or the estimated value of power to the users in cases where an alternative to Finchaa Sub-Basin plants may not exist or where alternative costs would exceed the maximum rates at which the power could be marketed. The alternative source most likely to be developed is an oil-fired, steam-electric powerplant located near the principal load center, Addis Ababa. The estimated power costs of alternative sources are obtained first for the Finchaa powerplant and second for the Neshe powerplant.

Although the installed capacity may be the same (80 mw.) for both the Finchaa and Neshe plants, the Neshe plant is capable of slightly greater annual energy generation than is the Finchaa.

Finchaa Hydroelectric Powerplant and Related Facilities

Equivalent Steam Plant at Akaki--Size and Description of Facilities. The Finchaa powerplant can deliver to the Addis Ababa load center a maximum of 343,692,000 kw.-hr. in an adverse water year, allowing for losses and system use. For an equivalent steam-electric plant located on the Aba Samuel Reservoir near Akaki (see Dwg. No. 4.0-BN-85) to deliver the same amount of energy to the same area as the Finchaa hydro, the Akaki steam plant would have to be capable of generating 365,436,000 kw.-hr. (gross) per year. This considers delivery at the same voltage, considers all losses, and also considers the much larger (five percent of gross) plant requirements for own use. The equivalent steam plant capacity would be 83.4 mw. The following characteristics were assumed.

Millions of B.t.u. per hour	=	433
Superheat temperature	=	950° F.
Operating pressure	=	1,360 p.s.i.g.

Steam Plant and Related Facility Construction Costs. Using steam plant boiler and generating facility cost curves developed for Ethiopia, the following costs were arrived at.

Boiler Plant	Eth$6,500,000
Generating facilities	25,000,000
Subtotal	Eth$31,500,000 (Eth$394/kw. or US$158/kw.)
Spur railroad, 7 km. long	441,000
Access road, 2-lane, gravel, 7 km.	464,000
Switchyard cost at steam plant	3,769,000
Transmission lines, 2 each, 132-kv., 28 km.	2,352,000
Receiving-end substation (switching only)	1,218,000
Total	Eth$39,744,000

Annual Operation and Maintenance Costs. Fuel costs (furnace oil) will be substantial, as this is an imported item. The fuel has been assumed to have 40,700 B.t.u./kg. and costs Eth$128/metric ton, based upon fuel costs for the Addis Ababa steam plant. A total of 93,292 metric tons of fuel oil would be required per year, costing Eth$11,941,376. The following costs were arrived at.

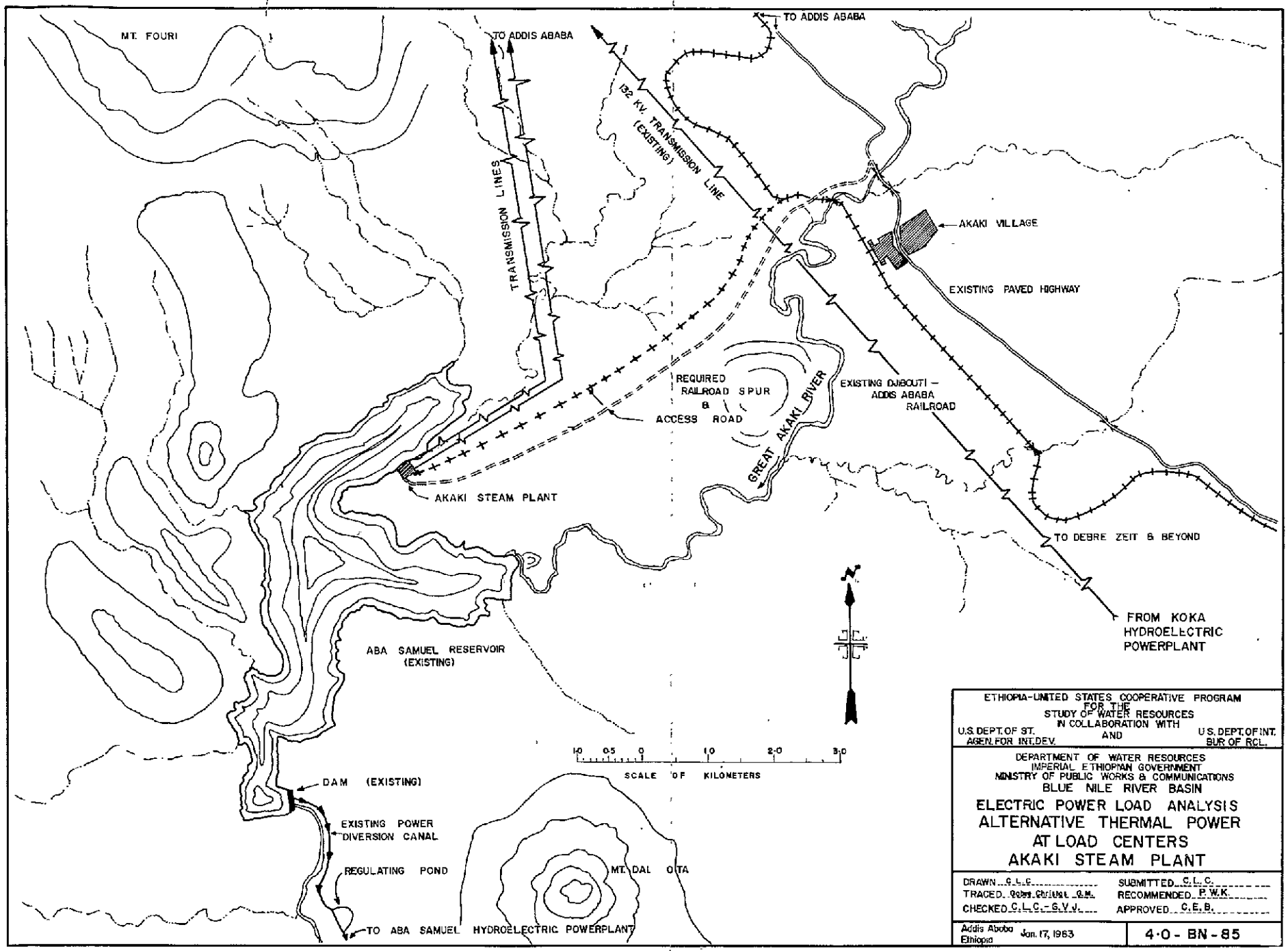
Fuel costs	Eth$11,941,376
O&M including lubrication oils	1,200,000
Road and railroad	11,000
Transmission lines and substation	35,000

Annual Fixed Costs. The present government-owned authority, EELPA, pays a substantial tax each year to governmental units. The amount used here is not intended to reflect the same tax rate but is used for both the hydro facilities and their alternatives.

Taxes and insurance	Eth$124,427
Replacement reserve, all facilities	697,569
Amortization	2,394,763

Annual replacement costs were computed on the basis of five percent for 50 years, using service lives estimated to reflect conditions in Ethiopia. This included a service life of 25 years for the steam plant.

Amortization was based upon a five percent interest rate at 50 years and also included amortizing the cost of interest during construction, amounting to Eth$3,974,400.


MT. FOURI
TO ADDIS ABABA
TO ADDIS ABABA
132 KV. TRANSMISSION LINE (EXISTING)
TRANSMISSION LINES
AKAKI VILLAGE
EXISTING PAVED HIGHWAY
REQUIRED RAILROAD SPUR & ACCESS ROAD
EXISTING DJIBOUTI – ADDIS ABABA RAILROAD
GREAT AKAKI RIVER
AKAKI STEAM PLANT
TO DEBRE ZEIT & BEYOND
FROM KOKA HYDROELECTRIC POWERPLANT
ABA SAMUEL RESERVOIR (EXISTING)
N
1.0 0.5 0 1.0 2.0 3.0
SCALE OF KILOMETERS
DAM (EXISTING)
EXISTING POWER DIVERSION CANAL
REGULATING POND
MT. DAL OTA
TO ABA SAMUEL HYDROELECTRIC POWERPLANT
ETHIOPIA-UNITED STATES COOPERATIVE PROGRAM FOR THE STUDY OF WATER RESOURCES IN COLLABORATION WITH
U.S. DEPT. OF ST. AGEN. FOR INT. DEV.
AND
U.S. DEPT. OF INT. BUR. OF RCL.
DEPARTMENT OF WATER RESOURCES
IMPERIAL ETHIOPIAN GOVERNMENT
MINISTRY OF PUBLIC WORKS & COMMUNICATIONS
BLUE NILE RIVER BASIN
ELECTRIC POWER LOAD ANALYSIS
ALTERNATIVE THERMAL POWER
AT LOAD CENTERS
AKAKI STEAM PLANT
DRAWN C.L.C.
TRACED Qebra Christos Q.M.
CHECKED C.L.C.-G.V.J.
SUBMITTED C.L.C.
RECOMMENDED P.W.K.
APPROVED C.E.B.
Addis Ababa Ethiopia Jan. 17, 1963
4-0-BN-85

Summary of Annual Costs. All annual costs can be summarized as shown below.

Operation, Maintenance, and Replacement	
Fuel costs	Eth$11,941,376
O&M steam plant, lines, substations	1,235,000
Road and railroad maintenance	11,000
Replacement reserve	697,569
Subtotal	Eth$13,884,945
Amortization	2,394,763
Other (taxes and insurance)	124,427
Total steam alternative	Eth$16,404,135
rounded to	Eth$16,400,000

Cost of Alternative Energy. Cost of energy at the same load point as that from Finchaa hydroplant is as follows:

$$\frac{\text{Eth\$16,400,000}}{343{,}692{,}000 \text{ kw.-hr./yr}} = \text{Eth4.77¢/kw.-hr. (US1.91¢/kw.-hr.)}$$

(Note: Eth4.72¢/kw-hr. at busbar, steam plant.)

Neshe Hydroelectric Powerplant and Related Facilities

Equivalent Steam Plant at Akaki (Acachi). Neshe facilities from the Finchaa Sub-Basin will follow some time after completion of the Finchaa powerplant. Its alternative source at load center is also a steam plant located at Akaki, as shown by Drawing No. 4.0-BN-85.

Size and Description of Facilities. The Neshe powerplant can deliver to the Addis Ababa load center a maximum of 360,457,000 kw.-hr. in an adverse water year, allowing for losses and system use. To deliver the same amount of energy to the same area as the Neshe powerplant, the Akaki steam plant would have to be capable of generating 383,263,000 kw.-hr. (gross) per year. This also considers delivery at the same voltage, considers all losses, and considers the larger plant requirements needed by steam electric powerplants (five percent of gross) for its own use.

The equivalent steam plant capacity would be 87.5 mw., and the plant would have the following assumed characteristics.

275

Millions of B.t.u. per hr.	=	455
Superheat temperature	=	950° F.
Operating pressure	=	1,360 p.s.i.g.

Steam Plant and Related Facility Construction Costs. The following costs have been arrived at.

Boiler plant	Eth$6,800,000
Generating facilities	26,000,000
Subtotal	Eth$32,800,000
	(Eth$375/kw. or US$150/kw.)
Spur railroad, 7 km. long	441,000
Access road, 2-lane, gravel, 7 km.	464,000
Switchyard cost at steam plant	3,769,000
Transmission lines, 2 each, 132 kv., 28 km.	2,352,000
Receiving-end substation (switching only)	1,218,000
Total	Eth$41,044,000

Annual Operation and Maintenance Costs. The same assumptions regarding fuel were made here as were used for the Finchaa Project study. However, a total of 97,957 metric tons would be required per year, costing Eth$12,538,500.

Annual operation and maintenance costs are estimated as follows.

Fuel	Eth$12,538,500
O&M including lubrication oils	1,200,000
Road and railroad	11,000
Transmission lines and substation	35,000

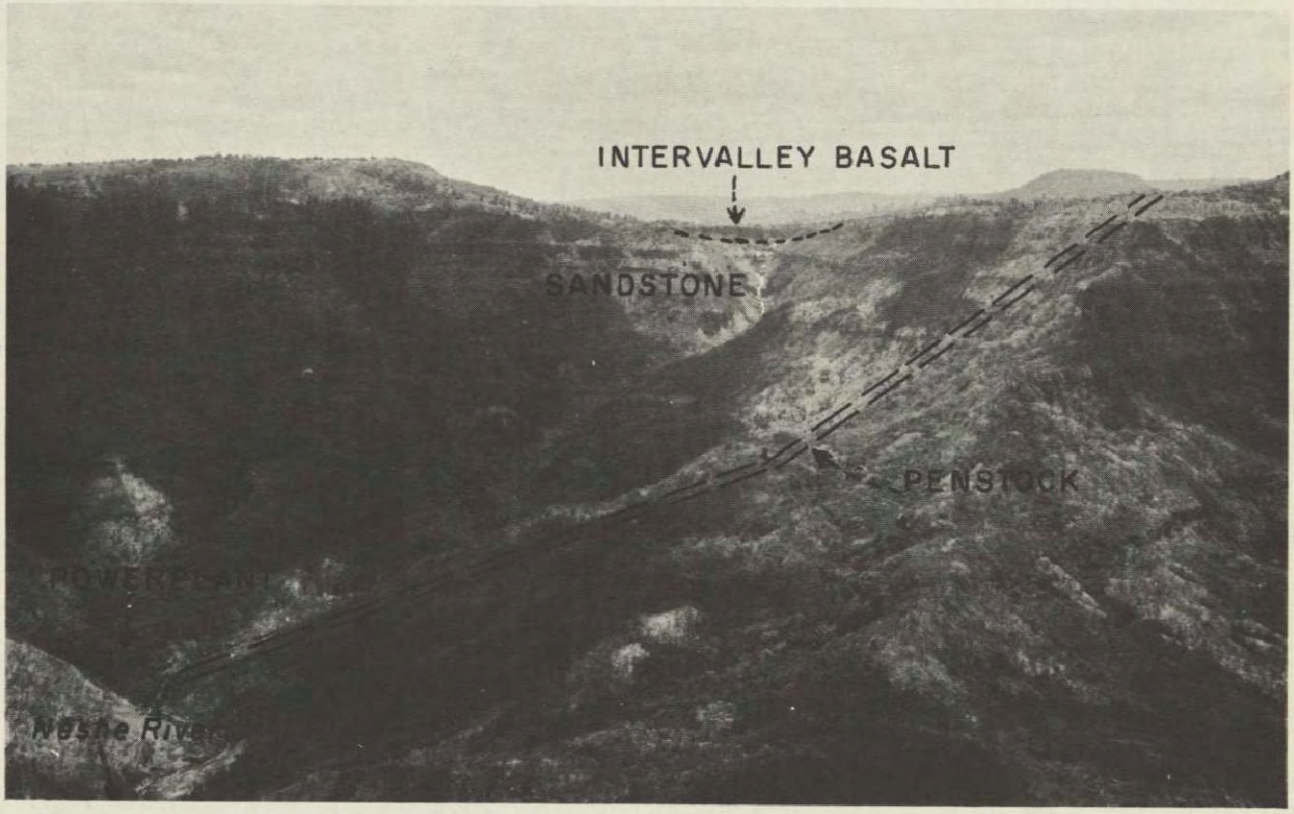
Annual Fixed Costs. Costs falling into this category were estimated as shown below.

Taxes and insurance	Eth$128,976
Replacement reserve, all facilities	724,869
Amortization	2,473,094

Summary of Annual Costs. Total annual costs can be summarized as shown in the following tabulation.

Operation, maintenance, and replacement	
Fuel costs	Eth$12,538,500
O&M steamplant, lines, substations	1,235,000
Road and railroad maintenance	11,000
Replacement reserve	724,869
Subtotal	Eth$14,509,369
Amortization	2,473,094
Other (taxes and insurance)	128,976
Total steam alternative	Eth$17,111,439
rounded to	Eth$17,110,000

276



NESHE POWERPLANT SITE - AMARTI - NESHE PROJECT

Cost of Alternative Energy. The cost of energy at the same load point as that from the Neshe hydroelectric powerplant is shown below.

$$\frac{\text{Eth\$17,110,000}}{\text{360,457,000 kw.-hr./yr}} = \text{Eth4.75¢/kw.-hr. (US1.90¢/kw.-hr.)}$$

(Note: Eth4.70¢/kw.-hr. at busbar, steam plant.)

Summary

The average cost of steam electric generating stations in the United States in 1960 was US$152.50 per installed kilowatt of capacity, 1/ exclusive of switchyard. The busbar energy cost averaged US0.69¢ per kilowatt-hour for all stations. This compares with the steam alternative for the Finchaa powerplant as follows:

Cost of installed capacity	US$158/kw.
Cost of energy at busbar	US$.0189/kw.-hr.

The cost of energy from Akaki steam plant would range from 1.4 to about 2.0 times that in the United States, while the cost per installed kilowatt is comparable, based upon a European plant installed at Akaki. The high energy cost is largely attributed to higher fuel costs.

1/ Electrical World, 12th Steam Station Cost Survey, Oct. 2, 1961.

278

SECTION VIII - ECONOMIC ANALYSIS

FINCHAA PROJECT

Benefits

Irrigation. Annual irrigation benefits of the Finchaa Project are expected to be Eth$8,936,000 under full development conditions. The gross crop method of analysis shows the the Finchaa Project has an expected annual post-project income of Eth$595.70 per hectare. There is no pre-project income, so the increased income arising from project development is the same Eth$595.70. Applied to the full project, the gross income is approximately Eth$8,936,000 annually.

This figure represents the gross value of crops expected to be produced in a single year under full development, assuming the stated crops, prices, and yields. Farm costs have not been deducted from this gross return, due to the lack of reliable and valid data. Consequently, the Eth$8,936,000 figure exceeds the net return to irrigation. It includes the direct benefits, which apply to the project area, and the indirect benefits, which apply to the economy outside the project.

Benefits from irrigation arise at the farm or project level, but are not confined there. Any farm expense, whether labor, supplies, or machine operation, represents farm costs, but creates a monetary benefit to the supplier of the goods or service. Benefits are widespread, since the purchase of a single item may involve not only the local retailer and wholesaler, but possibly a jobber and importer. Sales of farm products create a similar type of chain reaction.

To measure these indirect benefits, as well as the direct benefits where farm costs can neither be measured nor predicted accurately, the "gross crop income" method is used. Gross returns are computed for farming operations, under full development conditions, and represent the value of the irrigation project to the country as a whole. They are compared to the annual equivalent costs of the irrigation project, in a benefit-cost ratio.

219

Project labor will receive a large share of the benefits, since field labor, excluding farmers, will be required at the probable rate of one man per hectare. Benefits accruing to the dealers who handle, process, and market the crops, and to those who supply goods and services needed on the project, make up another large component. And still another monetary benefit will be the profits to farmers and to the project.

Many nonmonetary benefits will arise as a result of project development. The improvements in housing and diet, in sanitary and medical facilities, the increased opportunity to educate the children, the beginning of a rural land market, and the chance to acquire and practice new skills are important. But most important will be the creation of a class of independent, capable, commercial farmers. This is the final goal of the Finchaa Project and is probably the greatest single benefit that will be attributed to irrigation project development in Ethiopia.

No precise measurement of tax benefits to the national treasury is presented, but the pattern of levying taxes on agricultural projects in Ethiopia is well established. Therefore, a portion of the gross income would be paid in taxes each year. The amount could be known only after operations had commenced and governmental policy regarding land taxes and tithes, health and education taxes, and taxation of wages and private income had crystallized.

The effect of the investment on the Ethiopian economy should not be overlooked. Although plans regarding the source and amount of foreign and local capital are not yet formulated, certainly a major part of the capital would be of foreign origin. Construction of the multiple-purpose Finchaa Project will exceed Eth$91,000,000; the effect of a sum of this magnitude on the Ethiopian economy will be enormous.

Both the positive and the negative effects of this input of capital must be considered. Positive effects can take the form of increased demand and employment; negative effects, the form of inflation or the withholding of scarce physical resources from other segments of the economy during the construction period.

For any irrigation project there is a period between the initiation of development of project lands and full project development. This period, called a "lag," is of uncertain duration for the Finchaa Project, or indeed for any irrigation project in Ethiopia. Many questions regarding the rate of growth remain unanswered. But until full benefits are realized, the project cannot produce Eth$8,936,000 in gross crop value annually.

280

To offset the period before full project benefits are realized, a conservative approach is used for crop yields and land utilization. Yield figures are based upon similar irrigated areas and adjusted for the Finchaa valley. But they have not been projected upward for the future. Since commercial crops are constantly being improved, new varieties developed, and better techniques adapted, it is reasonable to assume that yields would be higher in the future. This is especially true because an experimental farm is planned for every irrigation project. If yields increase, monetary returns would be higher.

The cropping pattern projects only one planting of each crop per irrigation season. This also understates future income, since fuller utilization of project lands is probable after operations have become well established.

Consequently, ultimate crop income may well exceed the Eth$8,932,000 figure. This would tend to offset the early period when less than full returns were realized. It is probably more justifiable to assume that income greater than Eth$8,932,000 will be achieved toward the end of the development period, to balance or offset the early years when less was realized, than it is to attempt to predict the duration and the extent of the lag.

The contribution of the Finchaa Project to the gross national economy of Ethiopia should be considered. The G.N.P. of Ethiopia is expected to reach Eth$2,400,000,000 1/ by 1964. Under ultimate development the Finchaa Project should contribute Eth$25,336,000 yearly. Although the figures are not strictly comparable due to the lag in development and the techniques of computing irrigation and power benefits, still a contribution of this size would be significant to the agricultural, agricultural processing, electric power, and the manufacturing sectors of the economy.

Power. Two broad categories of power benefits are used: direct, and indirect and intangible. Direct power benefits are evaluated in monetary terms and comprise the only category used in this study to evaluate benefits when comparing with costs to arrive at a benefit-cost ratio. Indirect and intangible benefits, although very important, have not been evaluated in monetary terms in this study and hence are not included in the total annual monetary benefit used to compare with costs.

Direct power benefits are the values placed on the supplies of electric power and energy delivered at wholesale prices to municipalities, federal agencies, or privately owned public utilities. For this study, it could be the value placed on delivery to the EELPA at Addis Ababa.

1/USAID/Ethiopia, 1962.

281

In principle, the value or benefit of this service is the market price that EELPA would pay for designated amounts of particular classes of power and energy at specific times and points of delivery. In practice, direct power benefits are measured by the lesser of two figures--the estimated cost of the most economical alternative source of equivalent power likely to be developed in the market area in the absence of the project, or the estimated value of power to the users in cases where an alternative to IEG project development may not exist or where alternative costs would exceed the maximum rates at which the power could be marketed. For this study, it was determined that the alternative source of equivalent power would be an oil-fired steam plant located near Addis Ababa at Akaki. (See SECTION VII.) Direct power benefits by this method are estimated at Eth$16,400,000 annually. Power benefits may be realized at downstream powerplants as a result of planned water releases upstream. In this study, there are no existing downstream plants, but these may develop in the future.

Indirect and intangible power benefits, although not measured in monetary terms, occur by virtue of the existence and operation of the project features. For the Finchaa Sub-Basin Projects, these intangible benefits are as follows:

1. Effectuation of greater dependability and continuity of power service through the integration and coordination of Finchaa Sub-Basin powerplants with the Awash powerplants.

2. Contribution to effective industrial, commercial, and urban development to help achieve the national goal of transforming the present agricultural economy to an agricultural-industrial economy by 1982.

3. The making available of larger blocks of power useful in a national emergency, and so contributory to national security.

4. Conservation of foreign exchange by reduction of the need for importation of fossil fuels.

Some indirect benefits resulting from the construction of the Finchaa Sub-Basin Projects are as follows:

1. Sedimentation control. In the future, other reservoirs may be constructed downstream on the Blue Nile River, and in some small measure the Finchaa Project reservoirs will contribute toward the prolongation of the useful lives of downstream reservoirs, resulting in the extension of the power and other benefits that they may provide.

2. Fish and wildlife conservation. Ultimately, the reservoirs, when planted with the proper species, may provide a good source of fish to supplement the diets of the local people or even produce enough to warrant commercial development. The existing swamps produce no fish at present.

Of the indirect and intangible benefits, the contribution of the projects toward developing the industrial, commercial, and urban segments of the economy may be considered the most important. In a country which has no local supply of oil, coal, or other economical source of energy in commercial quantities, the necessity to import large quantities of fuel provides a deterrent to large scale development. Not only is imported fuel costly to use, but the import expenses can place a severe load on the economy which has to provide sufficient exports to meet the bill.

Ethiopia, with the establishment of the Koka dam and with continued additions to the hydroelectric power supply, including the Finchaa and Amarti-Neshe facilities, will solve the industrial fuel problem by providing for its own domestic source of power. It has or can obtain the other means of industrial production--labor, materials, and enterprise--although the latter is perhaps in short supply now.

Diversification of the economy, placing greater emphasis on industrialization, can form a basis for permanent improvement of living standards, in turn resulting in better health, education, and per capita income. The stimuli to industrialization provided by ample hydroelectric supplies are three:

1. By reducing initial costs of power installations and the total cost of providing power during the lifetime of any particular industrial concern.

2. By providing sufficient quantities of power, as and when required.

3. By providing flexibility in use of electricity as opposed to other forms of power.

The beneficial effects of industrialization as they apply to Ethiopia may be summarized as follows:

1. Greater use is made of Ethiopia's own resources so that a higher proportion of the final value of the country's products can be retained in the country, reducing imports.

2. A new class of artisans will be created which, in turn, necessitates and brings about a gradual improvement in educational standards. The new conditions of working and earning encourage the raising of living standards by giving the people incentives to own material things.

Costs

Construction. Construction costs for the multiple-purpose Finchaa Project, excluding land development costs, are Eth$86,127,000. These include Eth$16,112,000 for the irrigation facilities, Eth$65,177,000 for the power facilities, and Eth$4,838,000 for the joint-use facilities. Land development costs are Eth$5,325,000 and bring total construction and development costs to Eth$91,452,000. Construction costs are amortized over a fifty-year period at five percent interest.

Interest during Construction. Interest during the construction period is an economic cost of the Finchaa Project. It represents the cost of borrowing the funds required during the four- or five-year period of construction, preceding the fifty-year period of project operations. Benefits are calculated for the fifty years following construction, but the cost of borrowing the money before benefits are realized must be included to make the ratio of benefits to costs as complete as possible.

Simple interest is charged on monies borrowed to construct the project, and is amortized over the fifty-year period of analysis at five percent. Five years are required to construct the irrigation facilities, four years for the power and joint-use facilities.

Total interest during construction is Eth$9,015,500 (Eth$9,016,000). This includes Eth$2,014,000 for irrigation, Eth$6,517,700 for power, and Eth$483,800 for the joint-use facilities.

Development Costs. Land development constitutes two factors--land clearing and land leveling. The Finchaa Project area lies in the tropical savannah classification of Ethiopian forest and supports a heavy growth on the land. Clearing costs are expected to approximate Eth$230 per hectare, or Eth$3,450,000 for the entire project.

The land is moderately gentle to rolling, and leveling costs are expected to be Eth$125 per hectare, or Eth$1,875,000 for the project. Therefore, total land development costs should be Eth$5,325,000 for the project, or Eth$292,000 per year when amortized over the fifty-year period of analysis at five percent interest.

Operation, Maintenance, and Replacement Costs. Personnel expenses for operation, maintenance, and replacement of the Finchaa Project are expected to be about Eth$255,000 per year. Costs for equipment, supply, and general expenses should average Eth$285,000. Therefore, yearly costs for the irrigation function of the Finchaa Project should be Eth$540,000 annually. In addition, Eth$48,000 will be required yearly for operation, maintenance, and replacement of the portion of the joint-use facilities allocated to irrigation. Total costs then would be Eth$588,000 per year.

Other Costs. In addition to the construction, interest during construction, land development, and operation, maintenance, and replacement costs, still other costs exist for which no accounting is made in this reconnaissance study. These include the costs of constructing roads from the nearest highway into the project area, eradicating the present and potential diseases which make human life hazardous in the valley, acquiring the lands for project use, and the costs which are associated with land settlement.

A highway exists from Addis Ababa through the village of Gedo, the closest point to the Finchaa Project area. A trail north from Gedo to the hamlets of Shambo and Haratu is not usable for heavy hauling, nor does it extend to the Finchaa valley.

Although access roads are planned as costs of the project, these will cover only the distance from the edge of the escarpment to the lower end of the project. Therefore, a road is required from Gedo to the escarpment edge, a distance of some 60 to 70 kilometers. The construction, which would involve considerable cost to the government, would probably be delegated to the Imperial Highway Authority.

At present the valley is uninhabited; this is thought to be because animal and human diseases make the area unsafe for life and livelihood. Cattle diseases are less important, because stock will be kept only on a small scale (see "Livestock"). Nevertheless, animal health should be considered by the Ministry of Agriculture. Human disease is a paramount problem. The Anopheles mosquito and the Glossina tsetse fly make vector control necessary. And equally important is the danger of bilharziasis, a disease which does not now exist in the Finchaa valley. Bilharziasis or schistomiasis is a water-borne sickness which tends to follow the introduction of irrigation in Africa. The disease is caused by a group of blood flukes (Schistosoma species) and is carried by certain fresh-water snails (Bulinus or Physopsis species). Control of the snails is essential, and they appear to thrive in such shallow watery areas as irrigation canals and ditches. Costs of combating bilharziasis, other water-borne diseases, and injurious insects may be high for irrigation projects. Cooperation with the Ministry of Health is essential.

No costs have been assigned for the acquisition of project lands. Inasmuch as the Finchaa valley is unoccupied, no major expenses should be involved, although the local people living in the Chomen Swamp may claim ownership of the land.

Settlement costs and social and technical services are not included. A permanent camp is planned, but this is not intended to house farmers or laborers. Costs involved in moving people into the area and providing them the necessities until they can become self-supporting will require consideration in a detailed study. The cost of educating the children, providing sanitation systems and other social overhead services, and paying the agricultural, engineering, and health education specialists should be considered later. Each of these costs, whether for road construction, disease control, or acquiring and settling land, is real and must be considered when a final evaluation of the Finchaa Project is made. The sum of all costs should be measured against expected benefits to develop a more refined benefit-cost ratio, and to present precise financial data when a project loan is requested.

Annual Cost Equivalents. To determine the ratio of benefits to cost for the multiple-purpose Finchaa Project, annual equivalent costs are compared to annual benefits. Table VIII-1 summarizes the costs on a fifty-year and an annual equivalent, at five percent interest. All figures are shown in thousands of Ethiopian dollars.

Benefit-Cost Analysis

Annual benefits from the Finchaa Project, under full development conditions, are Eth$25,336,000. Annual equivalent costs are Eth$7,373,000, assuming a fifty-year period of analysis and a five percent rate of interest.

On this basis, the ratio of benefits to cost for the Finchaa Project is:

$$\frac{\text{Eth\$25,336,000}}{\text{Eth\$ 7,373,000}} = 3.44 \text{ to } 1.00$$

The following cost allocation discussion allocates the joint costs, in order to determine separate benefit-cost ratios for irrigation and power.

TABLE VIII-1 - SUMMARY OF COSTS AND ANNUAL COST EQUIVALENTS
FINCHAA PROJECT (ETH$1,000)

Feature	Construction cost	Interest during Construction	Capital costs	Annual: Interest and Amortization	Annual: OM&R	Annual: Total
		Irrigation				
Diversion dam	545	68	613			
East Main Canal	3,031	379	3,410			
West Main Canal	1,989	249	2,238			
Distribution and drainage system	10,547	1,318	11,865			
Land development	5,325	-	5,325			
Subtotal, irrigation	21,437	2,014	23,451	1,285	540	1,825
		Power				
Diversion dam	210	21	231			
Powerplant	11,015	1,102	12,117			
Power tunnel	32,948	3,295	36,243			
Transmission lines, etc.	21,004	2,100	23,104			
Subtotal, power	65,177	6,518	71,695	3,927	1,224	5,151
		Joint facilities				
Finchaa Dam and Reservoir	682	68	750			
Access roads	1,812	181	1,993			
Permanent camp	2,344	235	2,579			
Subtotal, Joint facilities	4,838	484	5,322	291	106	397
Total	91,452	9,016	100,468	5,503	1,870	7,373

Cost Allocation. There are two separate functions of the multiple-purpose Finchaa Project--irrigation and power. Some physical facilities are constructed specifically to serve irrigation, others specifically to serve power. Several, including the Finchaa Dam, the access road, and the permanent camp, are joint facilities constructed to serve both functions. The total costs of irrigation and power, therefore, are the cost of the facilities constructed specifically for that function, plus a portion of the costs of the joint facilities.

The Alternative Justifiable Expenditure method of cost allocation allocates costs of multiple-purpose projects according to a maximum allocation, a minimum allocation, and a sharing of joint costs. The maximum allocation, called the justifiable expenditure, is the highest cost that can be assigned to a function. This figure is the lesser of either the benefits expected to arise from construction and operation of the project, or of the costs of obtaining the same amount of benefit from the most likely alternative built in the absence of the project. The minimum allocation is the lowest cost which can be assigned to a function. It is the specific cost, or the cost which would be incurred only for irrigation or only for power. Specific costs include such facilities as the irrigation diversion dam, the powerplant, or the power tunnel. The joint costs are for facilities which are constructed to serve both functions, such as the Finchaa Dam or the access roads.

The allocation for irrigation or power is less than the maximum allocation but greater than the minimum allocation. It consists of the specific costs for each function, plus a sharing of the joint costs.

For the Finchaa Project, the costs of building the most likely alternative for both irrigation and power are less than the expected benefits which will arise from construction and operation of the project. The alternative costs, therefore, are the justifiable expenditure. The specific costs of irrigation are subtracted from the justifiable expenditure of irrigation; the same is done for power. The remainders are called the remaining justifiable expenditure. They are added together, and divided proportionally between irrigation and power.

Joint costs are then allocated to irrigation and power by these percentages, and added to the specific costs of each function. Therefore, total allocated costs of irrigation and of power are the sum of the specific costs of each function, plus a share of the joint costs.

Table VIII-2 lists specific and joint costs of the Finchaa Project, and Table VIII-3 allocates costs according to the Alternative Justifiable Method.

TABLE VIII-2 - SPECIFIC AND JOINT COSTS OF THE FINCHAA PROJECT
(Eth$1,000)

Item	Construction	Interest during Construction	Annual OM&R	Present worth OM&R	Total
Specific costs					
Irrigation	21,437 1/	2,014 2/	(540)	9,858	33,309
Power	65,177	6,518	(1,224) 3/	22,345	94,040
Joint costs	4,838	484	(106)	1,935	7,257
Total	91,452	9,016	(1,870)	34,138	134,606

1/Construction Eth$16,112
Development 5,325
21,437

2/Interest during construction is not applied on development costs.

3/Operation, maintenance, and replacement Eth$1,126
Taxes and insurance 98
1,224

289

TABLE VIII-3 - ALLOCATION OF COSTS OF THE FINCHAA PROJECT, BY USE OF THE ALTERNATIVE JUSTIFIABLE METHOD (ETH$1,000)

Item	Irrigation	Power	Total
Costs to be allocated			134,606
1. Annual benefits	8,936	16,400	25,336
Benefits capitalized	163,135	299,397	462,532
2. Alternative costs	37,742	99,326	137,068
Construction	24,322 1/	68,672	92,994
Interest during construction 2/	2,375	6,867	9,242
OM&R	11,045	23,787	34,832
(Annual OM&R)	(605)	(1,303)	(1,908)
3. Justifiable expenditure	37,742	99,326	137,068
4. Specific costs	33,309	94,040	127,349
Construction	21,437 1/	65,177	86,614
Interest during construction 2/	2,014	6,518	8,532
OM&R	9,858	22,345	32,203
(Annual OM&R)	(540)	(1,224)	(1,764)
5. Remaining justifiable expenditure	4,433	5,286	9,719
6. Percentage distribution	45.6	54.4	100.0
7. Allocated joint costs	3,309	3,948	7,257
Construction	2,206	2,632	4,838
Interest during construction	221	263	484
OM&R	882	1,053	1,935
(Annual OM&R)	(48)	(58)	(106)
8. Total allocated costs	36,618	97,988	134,606
Construction	23,643	67,809	91,452
Interest during construction	2,235	6,781	9,016
OM&R	10,740	23,398	34,138
(Annual OM&R)	(588)	(1,282)	(1,870)

1/Includes land development costs of Eth$5,325
2/No interest during construction is charged on land development costs.

Benefit-Cost Analysis, Irrigation. Annual irrigation benefits are Eth$8,936,000 and total costs allocated to irrigation are Eth$36,618,000. Table VIII-4 reduces irrigation costs to an annual equivalent basis, and indicates that annual costs chargeable to irrigation are Eth$2,006,000.

TABLE VIII-4 - SUMMARY OF IRRIGATION COSTS, FINCHAA PROJECT (ETH$1,000)

Feature	Construction	Interest during Construction	Capital costs	Annual		
				Interest and Amortization	OM&R	Total
East Main Canal	3,031	379	3,410			
West Main Canal	1,989	249	2,238			
Distribution and drainage system	10,547	1,318	11,865			
Service facilities	1,895	190	2,085			
Subtotal, canal system	17,462	2,136	19,598	1,074	577	1,651
Finchaa Dam and Reservoir	311	31	342		10	
Irrigation diversion dam	545	68	613		1	
Subtotal, diversion and storage system	856	99	955	52	11	63
Land development	5,325	-	5,325	292	-	292
Total	23,643	2,235	25,878	1,418	588	2,006

On this basis, the ratio of benefits to costs for irrigation is:

$$\frac{\text{Eth\$8,936,000}}{\text{Eth\$2,006,000}} = 4.45 \text{ to } 1.00$$

291

Benefit-Cost Analysis, Power. Annual power benefits are Eth$16,400,000 and total costs allocated to power are Eth$97,988,000 Table VIII-5 reduces power costs to an annual equivalent basis, and indicates that annual costs chargeable to power are Eth$5,367,000.

TABLE VIII-5 - SUMMARY OF POWER COSTS, FINCHAA PROJECT (Eth$1,000)

Feature	Construction	Interest during Construction	Capital costs	Annual		
				Interest and Amortization	OM&R	Total
Power diversion dam	210	21	231			
Powerplant	11,015	1,102	12,117			
Power tunnel	32,948	3,295	36,243			
Subtotal, power generation	44,173	4,418	48,591	2,662	704	3,366
Transmission plant	21,004	2,100	23,104			
Service facilities	2,261	226	2,487			
Subtotal, transmission and service facilities	23,265	2,326	25,591	1,401	565	1,966
Finchaa Dam and Reservoir	371	37	408	22	13	35
Total	67,809	6,781	74,590	4,085	1,282	5,367

On this basis, the ratio of benefits to costs for power is:

$$\frac{\text{Eth\$16,400,000}}{\text{Eth\$ 5,367,000}} = 3.06 \text{ to } 1.00$$

292

AMARTI-NESHE PROJECT

Benefits

Irrigation. Annual irrigation benefits of the Amarti-Neshe Project are expected to be Eth$5,062,000 under full development conditions. The gross crop income method of analysis shows that the Amarti-Neshe Project has an expected post-project income of Eth$595.70 per hectare. There is no pre-project income, so the increased income arising from project development is the same Eth$595.70 per hectare. Applied to the full project, gross crop income is approximately Eth$5,062,000 annually.

This gross income, or gross annual benefit arising from irrigation, will produce a similar reaction on the Ethiopian economy as the irrigation benefit from the Finchaa Project. However, the extent of the reaction will be less, since the gross benefit is smaller for the Amarti-Neshe Project.

Power. The same general statements made for the Finchaa Project apply here. The direct power benefit was arrived at in the same manner--i.e., using the alternative cost principle based upon a steam electric powerplant located near Addis Ababa. (See SECTION VII.) Direct power benefits by this method are estimated at Eth$17,110,000 annually.

The indirect and intangible power benefits to which no monetary value has been assigned are as outlined for the Finchaa Project.

Costs

Construction. Construction costs for the proposed multiple-purpose Amarti-Neshe Project, excluding land development costs, are Eth$123,020,000. These include Eth$9,487,000 for the irrigation facilities, Eth$56,274,000 for the power facilities, and Eth$57,259,000 for the joint-use facilities. Land development costs of Eth$3,014,000 bring total construction and development costs to Eth$126,034,000. Construction costs are amortized over a fifty-year period at five percent interest.

Interest during Construction. Interest during the construction period for the Amarti-Neshe Project is Eth$12,539,175 (Eth$12,539,000). This includes Eth$1,185,875 for irrigation, Eth$5,627,400 for power, and Eth$5,725,900 for the joint-use facilities. Interest during construction is amortized over a fifty-year period at five percent interest.

Development Costs. The Amarti-Neshe Project lies in the tropical savannah classification of lowland Ethiopian forest, and the vegetative growth on the project area is of sufficient thickness to classify the clearing costs as "heavy". Clearing costs are expected to approximate Eth$230 per hectare, or Eth$1,952,700 for the entire 8,490-hectare project.

The Amarti-Neshe Project area is gentle to rolling and falls into the "moderate" category of leveling. This category carries a charge of Eth$125 per hectare, or Eth$1,061,250.

Total clearing and leveling charges, collectively called development costs, are Eth$3,013,950 (Eth$3,014,000). Annual charges, determined by using the five-percent, fifty-year period factor, are Eth$165,000.

Operation, Maintenance, and Replacement Costs. Personnel costs required to operate and maintain the distribution and storage system of the 8,490-hectare Amarti-Neshe Project should be Eth$173,000 yearly. Costs for equipment, supplies, and general expenses will be approximately Eth$178,000 annually, for a total of Eth$351,000. In addition, Eth$31,000 will be required annually for operation, maintenance, and replacement of the portion of the joint-use facilities allocated to irrigation. Total costs then would be Eth$382,000 per year.

Other Costs. The same type of additional costs expected in the Finchaa area will apply to the Amarti-Neshe area. The costs of combating diseases, settling people in this new area, and social and

technical services will be substantial for this area, as they will be for the Finchaa. However, there will be no need to construct a road from Gedo, since this will be done for the Finchaa Project. Furthermore, unit costs of other factors may be cheaper, due to experience gained when developing the Finchaa.

Annual Cost Equivalents. To determine the ratio of benefits to costs of the multiple-purpose Amarti-Neshe Project, the annual equivalent costs are compared to annual benefits. Table VIII-6 summarizes the costs on a fifty-year and on an annual equivalent basis, at five percent interest.

TABLE VIII-6 - SUMMARY OF COSTS AND ANNUAL COST EQUIVALENTS--
AMARTI-NESHE PROJECT (ETH$1,000)

Feature	Construction costs	Interest during construction	Capital Costs	Annual		
				Interest and amortization	OM&R	Total
Irrigation						
Diversion dam	280	35	315			
South Main Canal	1,994	249	2,243			
North Main Canal	979	123	1,102			
Distribution and Drainage System	6,234	779	7,013			
Land Development	3,014	-	3,014			
Subtotal, irrigation	12,501	1,186	13,687	750	351	1,101
Power						
Powerplant	37,247	3,725	40,972			
Power tunnel	2,251	225	2,476			
Power canal	2,213	221	2,434			
Transmission lines, etc.	14,563	1,456	16,019			
Subtotal, power	56,274	5,627	61,901	3,391	1,244	4,635
Joint Facilities						
Amarti dam and reservoir	12,267	1,227	13,494			
Neshe dam and reservoir	39,867	3,987	43,854			
Access roads	2,938	294	3,232			
Permanent camp	2,187	218	2,405			
Subtotal, joint facilities	57,259	5,726	62,985	3,450	129	3,579
Total	126,034	12,539	138,573	7,591	1,724	9,315

295

Benefit-Cost Analysis

Annual benefits from the Amarti-Neshe Project under full development conditions are Eth$22,172,000. Annual equivalent costs are Eth$9,315,000, assuming a fifty-year period of analysis and a five-percent rate of interest. On this basis, the ratio of benefits to costs for the Amarti-Neshe Project is:

$$\frac{\text{Eth\$22,172,000}}{\text{Eth\$ 9,315,000}} = 2.38 \text{ to } 1.00$$

The following cost allocation discussion allocates the joint costs, in order to arrive at separate benefit-cost ratios for irrigation and for power.

Cost Allocation. The Alternate Justifiable Expenditure method of cost allocation is used to allocate joint costs of the Amarti-Neshe Project between irrigation and power. Table VIII-7 lists the specific and joint costs of the project, and Table VIII-8 allocates costs according to this method.

TABLE VIII-7 - SPECIFIC AND JOINT COSTS OF THE AMARTI-NESHE PROJECT (ETH$1,000)

Item	Construction	Interest during Construction	Annual OM&R	Present Worth, OM&R	Total
Specific Costs					
Irrigation	12,501 1/	1,186 2/	(351)	6,408	20,095
Power	56,274	5,627	(1,244) 3/	22,710	84,611
Joint Costs	57,259	5,726	(129)	2,355	65,340
Total	126,034	12,539	(1,724)	31,473	170,046

1/ Construction $9,487
Development 3,014
12,501

2/ Interest during construction is not applied on development costs

3/ Operation, maintenance, and replacement $1,160
Taxes and insurance 84
1,244

296

TABLE VIII-8 - ALLOCATION OF COSTS OF THE AMARTI-NESHE PROJECT BY USE OF THE ALTERNATIVE JUSTIFIABLE METHOD (ETH$1,000)

Item	Irrigation	Power	Total
Costs to be allocated			170,046
1. Annual benefits	5,062	17,110	22,172
Benefits capitalized	92,411	312,359	404,770
2. Alternative costs	40,592	148,225	188,817
Construction	29,276 1/	112,345	141,621
Interest during construction 2/	3,283	11,235	14,518
OM&R	8,033	24,645	32,678
(Annual OM&R)	(440)	(1,350)	(1,790)
3. Justifiable expenditure	40,592	148,225	188,817
4. Specific costs	20,095	81,611	104,706
Construction	12,501 1/	56,274	68,775
Interest during construction 2/	1,186	5,627	6,813
OM&R	6,408	22,710	29,118
(Annual OM&R)	(351)	(1,244)	(1,595)
5. Remaining justifiable expenditure	20,497	63,614	84,111
6. Percentage distribution	24.4	75.6	100.00
7. Allocated joint costs	15,943	49,397	65,340
Construction	13,971	43,288	57,259
Interest during construction	1,397	4,329	5,726
OM&R	575	1,780	2,355
(Annual OM&R)	(31)	(98)	(129)
8. Total allocated costs	36,038	134,008	170,046
Construction	26,472	99,562	126,034
Interest during construction	2,583	9,956	12,539
OM&R	6,983	24,490	31,473
(Annual OM&R)	(382)	(1,342)	(1,724)

1/ Includes land development costs of $3,014.
2/ No interest during construction is charged on land development costs.

257

Benefit-Cost Analysis, Irrigation. Annual irrigation benefits are Eth$5,062,000, and total costs allocated to irrigation are Eth$36,038,000. Table VIII-9 reduces irrigation costs to an annual equivalent basis and indicates that total annual costs chargeable to irrigation are Eth$1,974,000.

TABLE VIII-9 - SUMMARY OF IRRIGATION COSTS--
AMARTI-NESHE PROJECT (ETH$1,000)

Feature	Construction costs	Interest during construction	Capital Costs	Annual		
				Interest and amortization	OM&R	Total
South Main Canal	1,994	249	2,243			
North Main Canal	979	123	1,102			
Distribution and Drainage System	6,234	779	7,013			
Service Facilities	1,250	125	1,375			
Subtotal, Canal System	10,457	1,276	11,733	643	375	1,018
Amarti Dam and Reservoir	2,993	299	3,292			
Neshe Dam and Reservoir	9,728	973	10,701			
Irrigation Diversion Dam	280	35	315			
Subtotal, Diversion and Storage System	13,001	1,307	14,308	784	7	791
Land Development	3,014	-	3,014	165	-	165
Total	26,472	2,583	29,055	1,592	382	1,974

On this basis, the ratio of benefits to costs for irrigation is:

$$\frac{\text{Eth\$5,062,000}}{\text{Eth\$1,974,000}} = 2.56 \text{ to } 1.00$$

Benefit-Cost Analysis, Power. Annual power benefits are Eth$17,110,000 and total costs allocated to power are Eth$134,008,000. Table VIII-10 reduces power costs to an annual equivalent basis, and indicates that annual costs chargeable to power are Eth$7,341,000.

TABLE VIII-10 - SUMMARY OF POWER COSTS--AMARTI-NESHE PROJECT, (ETH$1,000)

Feature	Construction costs	Interest during construction	Capital Costs	Annual		
				Interest and amortization	OM&R	Total
Power canal	2,213	221	2,434			
Powerplant	37,247	3,725	40,972			
Power tunnel	2,251	225	2,476			
Subtotal, power generation	41,711	4,171	45,882	2,513	731	3,244
Transmission plant	14,563	1,456	16,019			
Service facilities	3,875	388	4,263			
Subtotal, transmission and service facilities	18,438	1,844	20,282	1,111	590	1,701
Amarti Dam and Reservoir	9,274	927	10,201			
Neshe Dam and Reservoir	30,139	3,014	33,153			
Subtotal, storage system	39,413	3,941	43,354	2,375	21	2,396
Total	99,562	9,956	109,518	5,999	1,342	7,341

On this basis, the ratio of benefits to costs is:

$$\frac{\text{Eth\$17,110,000}}{\text{Eth\$ 7,341,000}} = 2.33 \text{ to } 1.00$$

SECTION IX - ADMINISTRATION AND OPERATION

Governmental and Administrative Organization

Administrative organizations responsible for the development of natural resources vary between nations, depending upon the objectives, laws, governmental policies, and availability of skills and financial supports. Responsibilities are frequently divided among several agencies. The need for a central organization to establish and apply uniform treatment to all sectors of development and to coordinate the multiple uses and demands upon resources is recognized.

Resource development, however, is so complex that its effects may reach to every unit of governmental organization, and all agencies of government will share an interest, some to a greater extent than others. Therefore, the agency that must administer the program should be so constituted as to recognize and consider the requirements and the responsibilities of other agencies of government.

Initially, the Water Resources Department, an established agency under the direction of the Ministry of Public Works and Communication, could become the agency to administer the program. It could probably better serve the needs of the Nation if it were an autonomous agency operating under the broad direction of a board consisting of representatives from the ministries and agencies of the Government sharing major interest in this field. The primary purposes of the Water Resources Department or any succeeding agency should be to conserve and safeguard the land and water resources, promote orderly economic development of these resources, protect existing rights, provide for equitable distribution and allocation of water between the various uses, and guide the development of projects to the greatest beneficial use for the enjoyment of the people of the Nation.

Since the role to be played by the Water Resources Department in the development of land and water resources projects has not as yet been clearly defined and since no determination has been made regarding the methods of financing projects or repaying of the costs of construction, it would seem desirable for the Imperial Ethiopian

Government initially to appoint an expert committee on resource development. The committee should consist of representatives of the various ministries and agencies, including represention from the Water Resources Department, supported by experienced consultants if required. It would review and study existing legislation and customs relating to the utilization of land and water resources and the responsibilities of the various governmental agencies in this field. This committee should recommend legislation as required to provide the authority for a centralized agency for the development of the Nation's land and water resources through the construction, operation, and maintenance of hydroelectric, irrigation, and related projects.

The committee should recommend:

1. A charter for the centralized agency, setting forth the objectives, authority, and responsibility.

2. A water code insuring adequate control and regulation of the use of water for power, agriculture, industry, and municipal and domestic supply.

3. A plan to consolidate and/or coordinate the activities of the various agencies now operating in this field.

4. A plan for financing the costs of projects and retirement of obligations.

The development of the basic organizational principles would then support the gradual development of an organizational structure for the agency and for specific projects similar to that discussed and illustrated in subsequent paragraphs.

Consideration should be given to the possible advantages of consolidating or merging existing agencies whose functions may overlap as the program for resource development gains momentum. The Surveys and Mapping Division of the Water Resources Department and the Mapping and Geography Institute might well be consolidated into one Geodetic Survey and Mapping Agency. The Ethiopian Electric Light and Power Authority and the Water Resources Department have a common purpose, except that the Water Resources Department must consider multiple-purpose projects. The two could be consolidated under a common board of directors with the former becoming the Power Division of the new organization. The existing Water Resources Department organization could become the Engineering, Irrigation, and Development Divisions, and the Administrative Divisions of the two agencies could combine under the new central organization. These consolidations would reduce the cost of administration; recognize the value of an existing, well trained, and successfully operating power

30

unit; and provide for more efficient management as the organization grows to meet the expanding needs of multiple-purpose projects.

Agricultural Operations

National Goals

The ultimate goal of agricultural development in Ethiopia is the more efficient use of the natural resources of the Nation to bring about greater production of agricultural products, improve the national economy, and create additional employment opportunities for the national labor force. At the same time, such development should also establish a system which will permit the emergence of a class of farmers who can successfully own and operate commercial farms and make independent managerial and cultural decisions. Such farmers would hold title to their lands, enjoy the benefits of a higher standard of living, and have a voice in the conduct of affairs of their community.

This goal, which appears to be most advantageous both to the farmer and to the Nation in higher production of agricultural goods and in a stable land owning class of independent farmers, is not one that can be attained easily or quickly. A proper framework of legislation providing for land ownership and tenure and for an equitable system of taxation and other reforms is necessary. Equally important is the development of the aptitudes and abilities, as well as the incentive and ambition, of the individual farmer.

Few farmers under the existing situation have the ability to operate a modern irrigated farm successfully without considerable assistance and guidance. The Ethiopian farmer of today is a subsistence producer, using antiquated tools and implements and raising those crops which will meet the immediate needs of his family. Storage facilities are poor; machinery and commercial fertilizers are unavailable; and the lack of roads and other transport facilities generally limits the area of marketing to the production area. The average Ethiopian family has an income of Eth$170 to Eth$300 per year.1/ This income, to which the rural Ethiopian has become accustomed, provides the bare necessities of life. Under these conditions, the farmer contributes only a small amount to the national economy, compared to his potential contribution if agricultural efforts were more efficiently organized.

Farm Family Income Objective

A stronger economy can be created if the farmer can acquire sufficient land and productive facilities to provide an adequate

1/Sample surveys made by Water Resources Department personnel in Shewa, Wellegga, and Gojjam Provinces in 1960 and 1961.

302

standard of living. The farmer's income level should enable him to pay for his farm over a period of years, provide adequate housing, educate his children, and put aside in savings an amount sufficient to meet emergencies and provide the necessities in later life when he is no longer able to perform productive labor.

Annual farm income must be increased to meet these objectives. Studies of potential production from farms under an irrigation development in the Finchaa valley indicate that, under full development, an average farm size would be 17 hectares (42 acres). Thus the Finchaa Project with an ultimate size of 15,000 hectares would be divided into 880 farm units. This number of units would provide farming opportunities for 880 families directly and, when laborers and their families are included, agricultural livelihood for about 65,000 people. It would also create off-farm employment opportunities for at least that many more.

The 17-hectare size would be sufficient to provide an adequate standard of living for the farm family, pay farm expenses, and provide a contingency factor for emergencies, capital savings, and a small fund for future taxation. This is based upon the land utilization pattern, crop prices, and yields outlined in Tables VI-4 and VI-7, SECTION VI. The improved level of living includes a better house, a more plentiful and varied diet, and proper medical and educational facilities. Estimates of income requirements to achieve these family living allowances are of a reconnaissance nature, based largely on surveys taken in Ethiopia in recent years, and are shown in Table IX-1.

TABLE IX-1 - CASH REQUIREMENT PER FAMILY

Item	Amount per year (Eth$)
Housing	30
Food	470
Beverages	151
Clothing	222
Utilities	226
Education	100
Health, religion, and entertainment	57
Sundries	106
Total	1,362

303

The Eth$1,362, plus the contingency, capital savings, and taxation factors, would be provided by the average 17-hectare farm unit.

Development Period

Since it is recognized that today there are few Ethiopian farmers who have the financial resources and the experience and knowledge of modern irrigated farming to permit them to assume full responsibility for immediately successful management and operation of project farms, a development period must be allowed. During this period, the farmers would require financial assistance in the form of long-term, low-interest loans; intensive technical assistance in agricultural practices; guidance in farm layout and operation and direction of field labor; and initially, some degree of management of their over-all operation. Also during this development period, the responsibilities for management and operation would gradually be shifted to the farmers as they demonstrate ability to initiate and execute appropriate managerial and operational decisions.

The physical characteristics of the Finchaa Project are such that the irrigation development can proceed by stages over a period of years. The initial stage on the Finchaa should include about 20 farms with development to be accelerated yearly, assuming satisfactory results, until the project is in full operation. With effective management, adequate technical guidance and assistance, acceptance of responsibility, and emergence of initiative on the part of the farmer, a 10- to 15-year development period may be adequate.

Settler Selection and Assistance

The selection of farmers, particularly in the early period, is of vital importance to the success of the project. Farmers should be willing to learn the procedures of modern farming or should have the educational background which would qualify them technically. They must be cooperative and willing workers. The College of Agriculture and the agricultural schools at Jima and Ambo should be excellent sources of candidates.

During the development period, the necessary clearing, land leveling, and farm unit layout should be scheduled to assure the proper expansion of cultivated land. A staff of technical experts provided by the Extension Service of the Ministry of Agriculture and other agencies, to guide and assist farmers during this period, should include the following:

Agronomist
Marketing Specialist
Field Operations Coordinator
Irrigation Engineer
Farm Equipment Specialist
Health and Sanitation Advisor
Education Advisor
Home Economist

Training Farm

In addition to the privately operated farms, a training farm approach offers possibilities for successful development. A number of eventual farm units could be combined and initially operated by the Manager of Agriculture (discussed in a subsequent paragraph) and his assistants. Ethiopian farmers would be employed in a temporary category of hired potential farmers. As they acquire competence and demonstrate a willingness to own and operate farm units, portions of this training farm area could be released from central management and placed under private control.

In this process, the selection of farmers is less critical because poor candidates could be removed in the early stages of operation before they were placed on private farms. Failure of a hired farmer would be less expensive in terms of time, financial support, extension service backing, and social capital than the failure of an independent farmer.

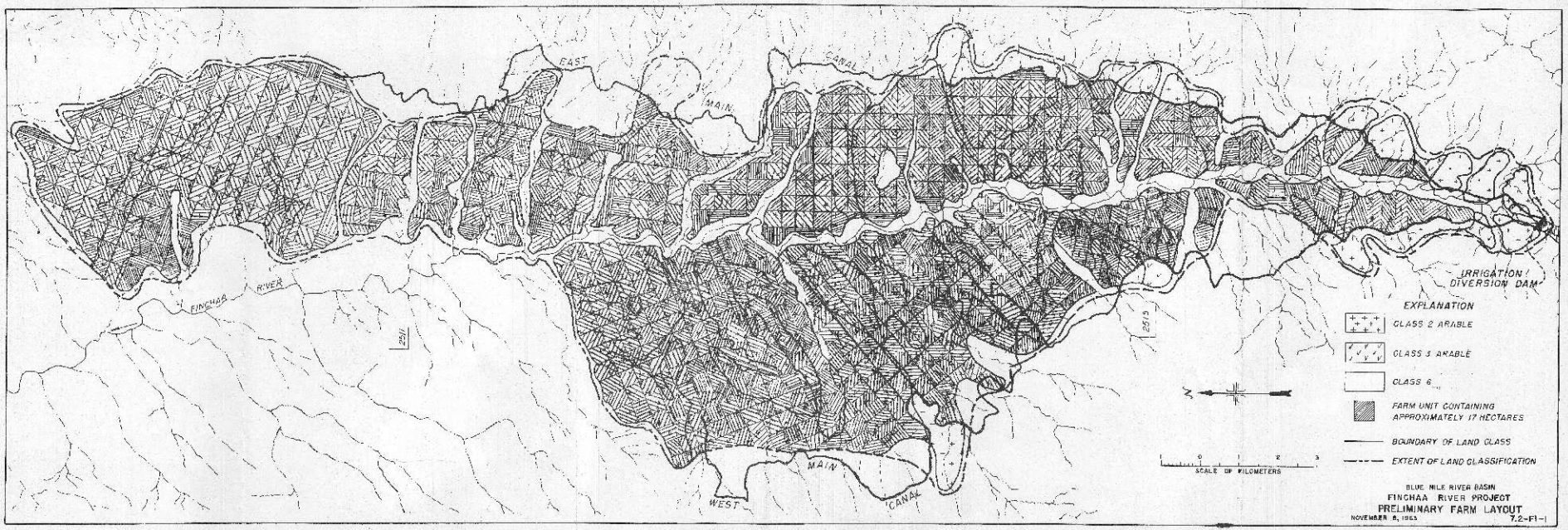
A training farm of approximately 340 hectares should be operated in this manner. This is equal in area to 20 independent farms. An operation of this magnitude would increase farm production, augment the number of men qualified to enter independent farming, and provide a gage to measure the relative success of the independent operations.

Drawing No. 7.2-Fi-1 shows the preliminary farm layout of the Finchaa Project.

Experimental Farm

The immediate establishment of a small experimental farm of several hectares in the Finchaa Project to test crops, cultural practices, machinery use, fertilizer and lime requirements, and insect, disease, and weed control is necessary. Such a unit should have permanent status and should constantly test new crops, varieties, and practices as well as provide a continuous check upon the older selections. Initially, this unit should confine its recommendations to crops selected in the cropping pattern but should, in the course

305



306 306A 306B 306C

of time, test the "exotic" or introduced crops which may become important in the future. An agronomist who is responsible to the Manager of Agriculture should direct this operation.

Manager of Agriculture

The Manager of Agriculture should supervise all Finchaa Project field operations. He must be well acquainted with all phases of commercial agriculture and modern irrigation and should possess proven ability to direct and encourage personnel. Ideally, he should be recruited from a successful irrigated plantation or farm with a good record of accomplishment and production. The salary paid should be sufficient to attract well-qualified personnel and should be supplemented by a share of profits for greater incentive. Since there are few large-scale irrigated farms in Ethiopia, it is possible that the first Finchaa Project Manager of Agriculture may be a foreign national. Later his position can be filled by an Ethiopian with the required technical background and well qualified by training on the job. Years of irrigation and commercial crop production and a knowledge of the myriad diverse factors producing successful operation are required on the part of such a manager if the project is to be successful.

The Manager of Agriculture should exercise full control over the training farm and a certain degree of regulation, decreasing with time, over the independent farmers. He should have the permanent functions of operating the experimental farm, developing the raw land, and operating and maintaining the irrigation storage and distribution system.

This manager with his staff of assistants should receive advisory service from the Agricultural Development Commission (discussed in a subsequent paragraph). He also requires staff assistance from technical specialists who are expert in various fields of agriculture, health, and education. These positions should concentrate their efforts upon the farmers but should not neglect the workers on the training farm, especially those nearing the stage of independent operations.

All personnel who perform direct service to the project, whether in the form of guidance, technical direction, operation of the distribution facilities, or management, should live at the project. This point is essential to avoid absentee direction. Absentee ownership of farms is also to be avoided. It is entirely possible that certain farmers may become successful enough to place their lands under a foreman and live in the city, but this should not be permitted. Every effort is necessary to demonstrate to the

farmers that this is their project and not the property of absentee owners residing in the capital or elsewhere.

Agricultural Development Commission

The concept of commercial irrigated farming is relatively new in Ethiopia, and consequently few farmers have had opportunity to gain experience in the field of modern agriculture. Partially to offset this situation, it is thought advisable to utilize the services of an Agricultural Development Commission at the project level, which would serve in an advisory capacity as the irrigation projects came into operation. A single commission should be created for the Finchaa Project and should be expanded to include responsibility for other projects as they develop in the immediate vicinity.

Ideally, the appointments for the Agricultural Development Commission should be made from agencies interested in resource development who could offer technical advice when so requested. The Ministry of Agriculture, the Ministry of National Community Development, the Ministry of Public Health, and the College of Agriculture could provide much needed technical support. Each commission should include representation from the project in the presence of at least one farmer familiar with local problems who can suggest solutions from the viewpoint of the project residents.

Future Studies

In any future study of the Finchaa Project the proposals which concern management should be further considered. The qualifications, duties, and salaries of the Manager of Agriculture, the technical experts, and the service personnel should be established. The appointment of members of the Agricultural Development Commission and their terms of office should be considered. And the processes for the selection of project farmers should be formulated. The overall personnel factor, of vital importance to project operations, should be studied thoroughly and recommendations made after careful consideration. Many other facets, which are only briefly mentioned in this section, should also receive careful attention.

Electric Power Operations

Central Organization

The present Ethiopian Electric Light and Power Authority is a well established and operated organization, and its charter states:

"The purpose of the Authority is to engage in the business of producing, transmitting, distributing and selling electrical energy to the public in Ethiopia and to carry on any other lawful business incidental or appropriate hereto which is calculated directly or indirectly to promote the interest of the Authority to enhance the value of its properties." 1/

Paragraph 4 of the same charter also states:

"..... the Authority shall have the powers: (f) to establish rates, charges, rules and regulations for the sale of its services and electrical energy." 1/

The charter thus implies that EELPA is a major agency in producing, transmitting, and marketing electrical energy in Ethiopia (excluding existing concession areas in Eritrea), and therefore any discussion of the future role that the Water Resources Department or any succeeding agency may have in this field would have to recognze this already established fact. A developing country cannot initially afford two separate governmental organizations competitively engaged in the public utility business, requiring some duplication of engineers, other specialists, and resultant costs, where such qualified personnel are in very short supply.

Phase I Operations. The present EELPA organization chart is shown by Drawing No. 4.0-BN-175. While the desirable objective may be in having only one autonomous governmental agency involved in the power generation, transmission, and marketing field, this can still be accomplished by EELPA and the Water Resources Department operating under the Phase I arrangement as shown by Drawing No. 4.0-BN-176. Phase I operations are also adaptable to any private power utility, should such come into existence in the future.

Under Phase I, EELPA becomes in effect the Power Division and is directly responsible for power operations, maintenance, and marketing. A common Board of Directors for both Water Resources and EELPA will provide for proper coordination where multiple-purpose projects are involved, but considerable responsibility is placed in the hands of the Board of Directors. The Assistant Manager (Power) for Multiple-Purpose Projects provides the necessary direct liaison between the managerial levels of the two agencies. Also, it is through this level that power planning activities of both agencies are coordinated. If EELPA assumes the operation, maintenance, and marketing responsibilities, then it should participate in the power planning activities.

1/General Notice No. 213 of 1956, Charter.

Enacting laws as recommended by the Government Committee could establish the concept of multiple-purpose projects requiring that a part of power revenues returned to the Federal Treasury be used in financing or retiring indebtedness incurred in the construction of multiple-purpose projects. At the same time, a reasonable return must be allowed the power operating agency. Establishing the details of such arrangements is beyond the scope of those reconnaissance investigations requiring average rate and repayment studies which in turn require considerably more detail and information than currently available.

The present charter for EELPA specifies the following item regarding taxation.

> "9. Taxation--The Authority shall be subject to all taxes and custom duties levied by the Imperial Ethiopian Government including Federal Taxes, and such local and municipal taxes as shall be approved by the Imperial Ethiopian Government." 1/

If the taxation obligation remains in its present form, then this will have a definite effect upon the rate of return required for any power operating agency from operation of the power facilities of multiple-purpose projects. The over-all effect will be to require higher rates than would otherwise be necessary. A reduction in tax obligations only on power generated from government-owned, water resource, multiple-purpose projects resulting in lower cost power may provide an added inducement for EELPA to participate as a partner under Phase I operations.

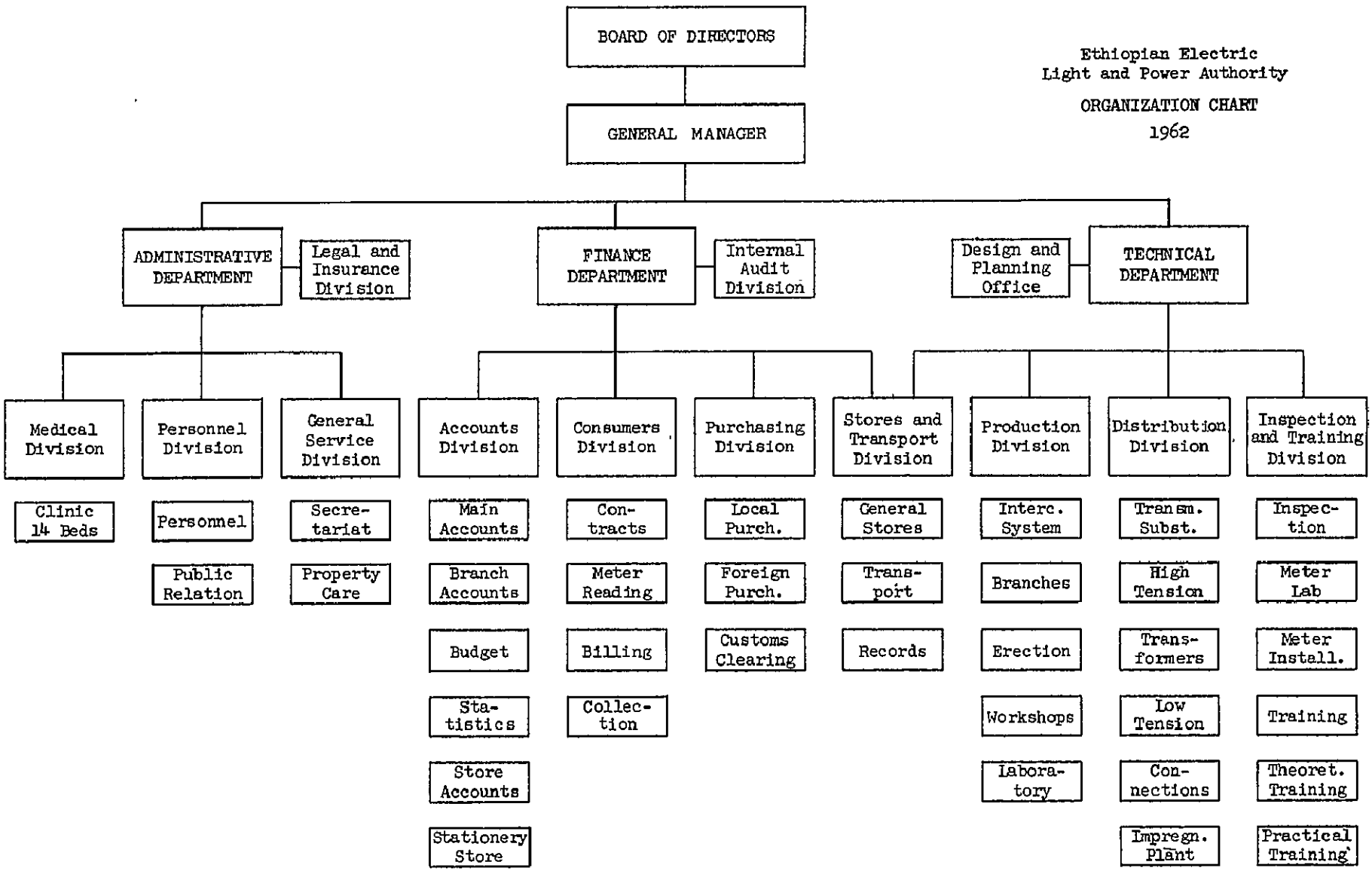
While it is possible for Phase I operations to continue indefinitely, a final step resulting in complete consolidation of the two agencies would be most desirable to afford greater economy and efficiency as has been the result in a number of other developing countries.

Phase II Operations. Under Phase II, both agencies would be combined as one autonomous agency. For convenience, it is referred to here as the Ethiopian Power and Water Resources Agency (EP&WRA), and in effect the former EELPA becomes the Power Division of the new agency and the Water Resources Department becomes the Engineering, Irrigation, and Development Divisions with the Administrative Division made up from the combined agencies. The new EP&WRA would be under a Board of Directors as shown on Drawing No. 4.0-BN-177, but administered by a General Manager. The Power Division would have four branches--Marketing, Planning, Operation and Maintenance, and Dispatching. The functions of each branch would be as described below.

1/General Notice No. 213 of 1956, Charter.

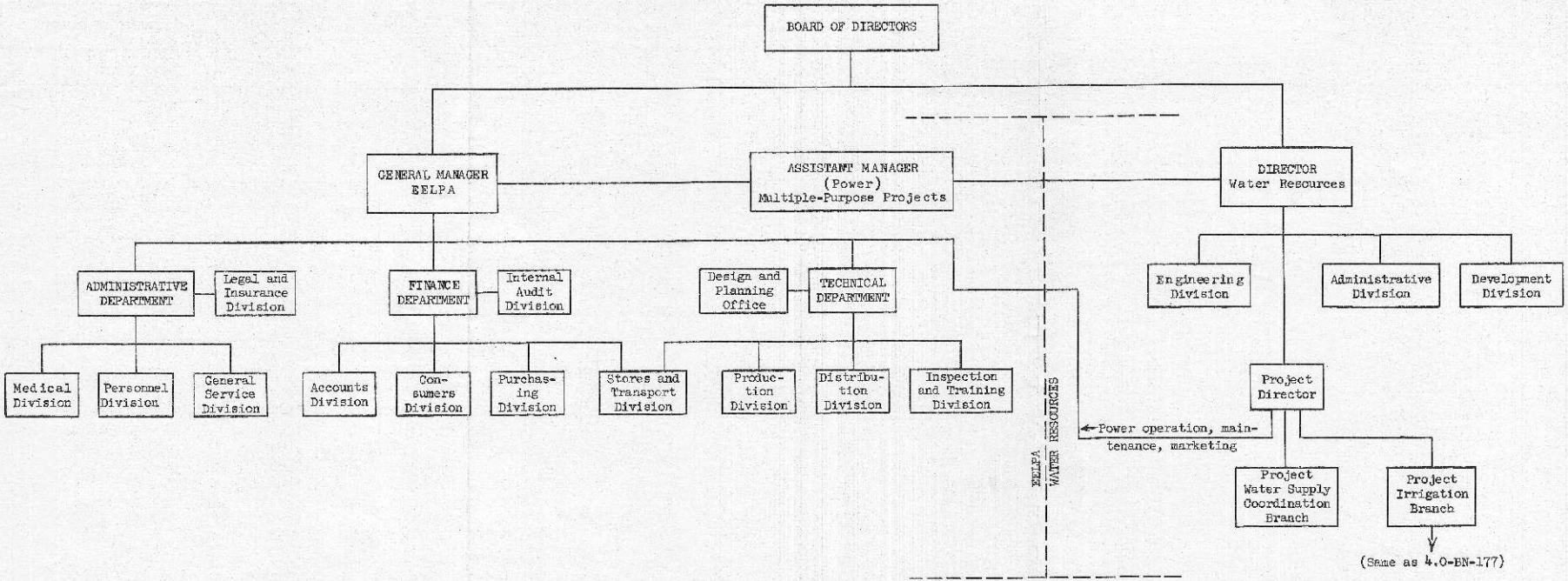
Ethiopian Electric
Light and Power Authority

ORGANIZATION CHART
1962



4.0-BN-175

3

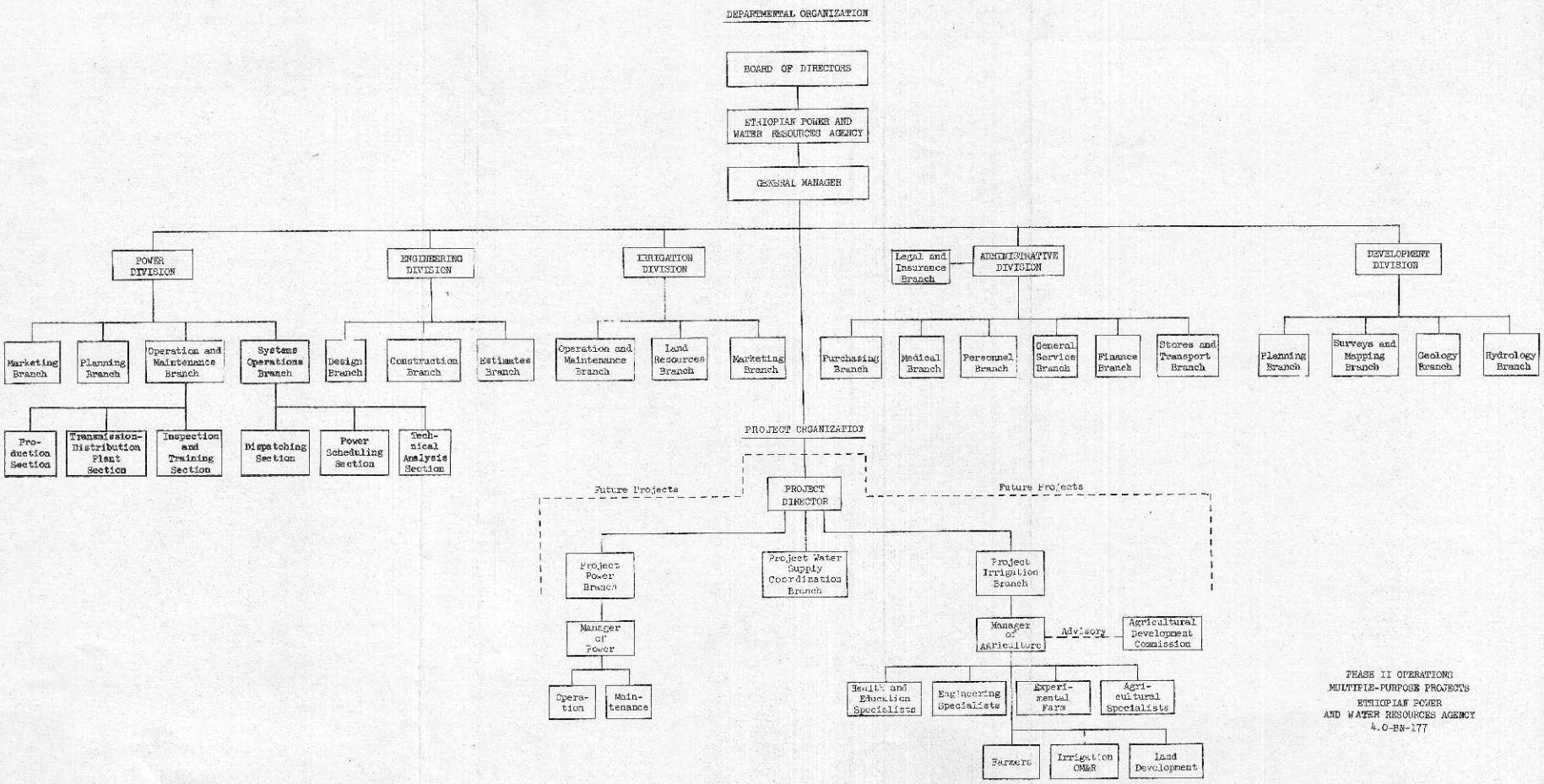


PHASE I OPERATIONS
MULTIPLE-PURPOSE PROJECTS
EELPA AND WATER RESOURCES DEPARTMENT
4.0-BN-176

312

312A

312B



PHASE II OPERATIONS
MULTIPLE-PURPOSE PROJECTS
ETHIOPIAN POWER
AND WATER RESOURCES AGENCY
4.0-BN-177

Marketing: This branch would be responsible for negotiating power sales contracts, reading meters, billing, and collection. It would also gather statistics and have available at all times a breakdown of sales by classes of loads--residential, rural, commerce, industry, street and highway lighting, transportation, and other. Such data would be available for use by the Planning Branch.

Planning: Load forecasting, feasibility studies for system additions, rate and repayment studies for the power aspects of multiple-purpose development, and technical power studies are among the duties of this branch.

Operation and Maintenance: This branch might have three sections--Production, Transmission-Distribution Plant, and Inspection and Training. On multiple-purpose projects, technical guidance (operation and maintenance) would be given the Project Power Branch, but the latter is administratively under the Project Director for the project. The Transmission-Distribution Plant Section would be responsible for maintenance of all transmission and distribution lines as well as substations and related equipment. It would also operate the wood-pole treating plants. In order to maintain an adequate supply of trained personnel, the Inspection and Training Section could teach linemen, powerplant operators, meter installers, laboratory technicians (transformer oil breakdown tests, meter testing, etc.), electricians, and inspectors. The latter would be for inspection of customers' premises as well as the agency's own facilities. This section would also be responsible for maintaining an adequate electrical wiring code and enforcing its provisions as well as providing maintenance for all communication facilities.

System Operations: This branch might also have three sections--Dispatching, Power Scheduling, and Technical Analysis. Initially, this branch's activities would be limited because of the simple nature of the system, but it would become more active as more generating stations and loads are added. In any event, its activities would be limited to the Interconnected System. The Dispatching Section would be responsible for meeting load requirements and schedules as well as for controlling all switching and clearances. The Power Scheduling Section would be responsible for developing system-wide scheduling on a day-to-day basis, consistent with scheduled water releases. The Technical Analysis Section would be responsible for system operation at maximum efficiency. Emergency switching programs and studies regarding system control (relays, etc.) would be the responsibility of this section.

Close liaison between the System Operations Branch and the Hydrology Branch under the Development Division would be required regarding reservoir operations. All reservoir operation studies

forecasting reservoir releases for appropriate advance periods should be made by Reservoir Operations, Hydro ogy Branch, under the Development Division. This information would be given to the System Operations Branch, Power Division as well as to each individual Project Director where multiple-purpose projects are in operation. The Project Director, through his Projects Water Supply Coordination Branch (Drawing No. 4.0-BN-177), would be finally responsible for implementing instructions received from Reservoir Operations. Drawing No. 4.0-BN-177 shows the Project Director and staff arrangement for a multiple-purpose project. For single-purpose power projects only, there would be no irrigation and therefore the Projects Water Supply Coordination Branch would not be concerned. Reservoir Operations supply the data to System Operations and to the Project Director.

Project Power Operations

Each project or convenient combination of projects, such as the Finchaa and the Amarti-Neshe, would be headed by a Project Director. Under the director is the Projects Power Branch, consisting of a power Manager heading two sections, an Operation Section and a Maintenance Section. These two operate the powerplants, taking hourly instructions from the Dispatching Branch, Central Office, and maintain the powerplant and appurtenant works. The function of the Projects Water Supply Coordination Branch has already been discussed.

For single-purpose power projects, the Power Director would have only two groups under him, one Operation and the other Maintenance, with the same responsibilities as before except that activities would not be restricted to the powerplant and appurtenances but would apply to all features of the project, including the storage facilities.