U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY

PRELIMINARY INDUSTRIAL SURVEY TROPICAL HARDWOODS UTILIZATION

DECEMBER 20, 1977

PULP AND PAPER DIVISION

MAIN

MAIN

CHAS. T. MAIN, INC.
SOUTHEAST TOWER, PRUDENTIAL CENTER, BOSTON, MASSACHUSETTS 02199 • TELEPHONE 617-262-3200

Mr. W.D. Roseborough
Office of Science & Technology
AID - Department of State
Washington, D.C. 20523

June 4, 1979

Dear Mr. Roseborough:

I enjoyed talking with you by phone, and appreciate your approval of our sending information from the Tropical Hardwoods Utilization Report to the Board of Investment in Manila, Philippines, as an example of MAIN's experience with tropical hardwood harvesting and pulping. As discussed, we will send the summary form of the report, which has been publicly distributed, and tables of contents and summary sections of the full report.

Enclosed, as you requested, is a copy of the report Preliminary Industrial Survey, Tropical Hardwoods Utilization prepared for the Forest Products Laboratory as a part of their study for you.

As discussed, I will be in contact by phone to set a convenient date to visit you and discuss the status of the project and our information received from the Department of Commerce on a potential study of a ASEAN pulp mill being coordinated by the Philippines Board of Investments.

Sincerely Yours,

CHAS. T. MAIN, INC.

Robert N. Zabe
Marketing Manager

cc: J.W. Swan

RNZ:zm

PN-AAF-396

MAIN
Engineers

CHAS. T. MAIN, INC.
SOUTHEAST TOWER, PRUDENTIAL CENTER, BOSTON, MASSACHUSETTS 02199 • TELEPHONE 617-262-3200

December 20, 1977 3254-1

SUBJECT: Preliminary Industrial Survey
Tropical Hardwoods Utilization

United States Department of Agriculture
Forest Service
Forest Products Laboratory
P.O. Box 5130
Madison, Wisconsin 53705

Attention: Mr. Charles B. Cameron
Contracting Officer

Gentlemen:

We submit, herewith, our report: Preliminary Industrial Survey for Tropical Hardwoods Utilization, authorized by your contract No. 12-226 on March 9, 1977.

The purpose of this study was to determine the potential for utilization of an existing natural resource in a developing country as a means of creating useful products; providing new employment opportunity; stimulating the economy; and improving the balance of trade; while observing due regard for conservation and ecological factors.

The scope of this report was to conduct a Preliminary Industrial Survey into the feasibility of harvesting run-of-the-woods tropical hardwoods for the manufacture of pulp and fiberboard, and for the production of steam and electrical energy from tropical hardwoods.

The wood harvesting and chip processing part of this study was conducted by H.C. Mason, Inc. The results of their study have been included without editing in Section 3 of this report.

The information used by MAIN in the presentation of this study was gathered from data obtained: at pulp mills presently manufacturing pulp and paper products from mixed tropical hardwoods; from the laboratory results of tests done by the U.S. Department of Agriculture Forest Service, Forest Products Laboratory; from Philippine and Colombian Governmental studies, from the United Nations Food and Agriculture Organization; and from our in-house information. We are grateful to those who have provided us with the information we required to conduct this study.

We thank you for this interesting assignment and trust that our report provides the information required for this part of your larger assignment with the Agency for International Development.

Very truly yours,

CHAS. T. MAIN, INC.

Robert N. Zabe
Project Manager

Richard J. Albert
Project Engineer

RNZ/RJA/em
cc: J.F. Laundrie w/5 reports
R.L. Nelson w/1 report

U.S. DEPARTMENT OF AGRICULTURE
FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

TABLE OF CONTENTS

Section	Subject	Page
1.	SUMMARY AND CONCLUSIONS	1.1 to 1.7
2.	INTRODUCTION	2.1 to 2.5
	BACKGROUND	2.6 to 2.9
3.	HARVESTING AND CHIP MANUFACTURING	3.1 to 3.70
4.	INFRASTRUCTURE	4.1 to 4.5
5.	BLEACHED KRAFT PULP MILL	
	General	5.1 to 5.3
	Personnel & Ecological Protection	5.4 to 5.8
	Process Systems	5.9 to 5.46
	Process Flow Diagram - Pulp Mill	5.47
	Plant Arrangement	5.48
	Heat Balance	5.49
	Significant Differences - Location	5.50 to 5.51
6.	IMPACT OF MIXED TROPICAL HARDWOODS TO AN EXISTING MILL	6.1 to 6.9
7.	FIBERBOARD PLANT	
	General	7.1 to 7.6
	Process Systems	7.7 to 7.16
	Investment Cost - Marketing	7.17 to 7.21
	Process Flow Diagram - Fiberboard	7.22
8.	PULP MARKETING	8.1 to 8.7
	Table 1 - Norscan Inventories	8.8
	Table 2 - Brazilian Pulp Industry	8.9
	Table 3 - Brazilian Pulp Potential	8.10
	Table 4 - Major Expansion Projects in Brazil	8.11
	Table 5 - World Outlook - Bleached Pulp	8.12
	Table 6 - Projected Philippine Demand for Paper and Paperboard	8.13

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December 20, 1977

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY

PRELIMINARY INDUSTRIAL SURVEY TROPICAL HARDWOODS UTILIZATION

DECEMBER 20, 1977

PULP AND PAPER DIVISION

MAIN

Section	Subject	Page
9.	FINANCIAL ANALYSIS BLEACHED KRAFT PULP MILL	9.1 to 9.9
	Appendix I - Investment Costs	9.10
	Table 1 - Total Investment Cost Summary	9.11
	Table 2 - Construction Costs By Year	9.12
	Table 3 - Total Investment Requirements by Year	9.13
	Table 4 - Direct Cost of Plant Capital	9.14
	Table 5 - Direct Cost of Plant Capital by Year	9.15
	Table 6 - Plant Capital Indirect Proportions by Year	9.16
	Table 7 - Plant Capital Indirect Costs by Year	9.17
	Appendix II - Investment Costs	9.18
	Table 8 - Working Capital	9.19
	Table 9 - Startup Costs	9.20
	Table 10 - Mill Related Infrastructure	9.21
	Appendix III - Manufacturing Costs	9.22
	Table 11 - Manufacturing Costs Summary	9.23 to 9.24
	Table 12 - Manufacturing Costs by Year	9.25
	Table 13 - Labor Costs	9.26
	Appendix IV - Financial Analysis	9.27
	Table 14 - $375/Ton Financial Analysis	9.28
	Table 15 - $425/Ton Financial Analysis	9.29
	Table 16 - $475/Ton Financial Analysis	9.30
	Table 17 - Sensitivity Tests - Return on Equity - Tabulated	9.31
	Table 18 - Sensitivity Tests - Return on Equity Graph	9.32
	Table 19 - Financing Schedules	9.33
	Table 20 - Amortization Schedule	9.34
	Table 21 - Amortization Schedule - Alternate Financing	9.35
	Table 22 - $375/Ton Financial Analysis - Alternate Financing	9.36

U.S. DEPARTMENT OF AGRICULTURE
FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

SUMMARY AND CONCLUSIONS

On March 9, 1977, MAIN was retained by the Forest Products Laboratory of the United States Department of Agriculture Forest Service to conduct a Preliminary Industrial Survey of Tropical Hardwoods Utilization.

The basis of this assignment was research directed at the harvesting and utilization of the run-of-the-woods species in the tropical forests of Southeast Asia, Latin America, and Africa. This survey gave primary consideration to Southeast Asia and determined significant differences for Latin America and Africa.

The survey requirements were divided into two major parts:

Wood Harvesting and Processing to Chips
Wood Chip Usage for Pulp, Fuel and Fiberboard

WOOD HARVESTING AND PROCESSING. -

H.C. Mason, Inc., conducted this part of the survey which called for preliminary engineering and cost analyses of a system to harvest and transport run-of-the-woods tropical hardwoods to a processing plant and the conversion of the logs to chips of a quality suitable for the manufacture of market pulp and building products, with any remainder to be used for fuel.

A. Harvest and transport 150,000 cubic feet of wood per day (8-hour day).

B. Process 150,000 cubic feet of rough wood as logs into chips per day.

C. Classify into grades suitable for market pulp, building products, and fuel.

It was assumed that the chip processing plant was located at the product manufacturing plant.

WOOD CHIP USAGE FOR PULP MANUFACTURE, FUEL AND FIBERBOARD. -

MAIN has conducted this part of the survey which called for preliminary estimates for:

A. A totally new facility for producing

- 500 tons per day of bleached market kraft pulp
- 100 tons per day of fiberboard

with fuel needs based on wood

B. Determination of the impact to an existing pulp mill using wood with properties similar to temperate zone hardwoods; with respect to economics and product quality, of conversion to run-of-the-woods tropical hardwoods for pulp and wood for fuel. (For mills presently using mixed tropical hardwoods, the impact would be only to wood handling and boiler.)

MAIN has also developed a checklist of infrastructure necessary and desirable for efficient operation, recommended implementation procedures, discussed the marketing considerations and presented a financial analysis of the facility.

The following general conclusions have been reached:

A. Harvesting and Manufacturing
New 500 T/D Kraft Pulp Mill

It is technically possible to harvest run-of-the-woods tropical hardwoods, convert this material to chips and manufacture market grades of bleached kraft pulp. It is also technically possible to substitute a substantial percentage wood for the oil which is normally used as fuel for generation of process steam and power.

The financial viability of this pulp mill was examined on the basis of the before tax discounted cash flow return on equity and debt service ratio which could be generated. The information developed from the financial analysis indicates that at an investment cost of $266,000,000; a direct manufacturing cost of $213.80/Air Dry Metric Ton and current market prices for pulp, a negative return on equity would result. Variations in the assumptions on investment cost, manufacturing costs and sales price demonstrate the sensitivity of return on equity to each of these factors. Reference to Table 18, Page 9.32 - Sensitivity Tests, indicates that changes in selling price have almost twice the effect on the internal rate of return as do changes in investment or manufacturing costs. Accordingly, it was learned that at an F.O.B. mill price of $375/Ton the before tax return on equity would be marginal; at $425/Ton the before tax return on equity would be approximately 8%; at $475/Ton the before tax return on equity would be 12%.

Clearly under present conditions this would not appear to be a viable project if the pulp mill is considered exclusively on its own merits.

Considerations which may alter the major conclusions include the following:

Governmental Incentives. Most pulp mill projects in developing countries have been sponsored by or assisted by the national government of that country. The government may contribute a percentage of the total investment cost as a grant in order to provide an incentive for other investors. The government may pay for general development costs such as the woodlands and infrastructure; or provide low interest loans, tax incentives or tariff protection. Any one or all of the above governmental incentives may be offered in order to improve the return on equity.

Specific Local Need. If the pulp is sold in local markets, the savings on shipping charges will favorably affect the return on equity.

Marketing. At present, there is an oversupply of hardwood kraft pulp on the world market. This has caused a reduction in the sales price. Indications are that, with the new hardwood kraft mills in Brazil coming into production, the oversupply will continue in the immediate future. Additional pulp mills being planned in Brazil, Southeast Asia and Africa may also add to the oversupply. However, the 1990 consumption projections for Japan and Western Europe show a potential market opportunity for hardwood kraft pulp as an import.

Employment. This facility will provide direct employment for 1340 people. While the capability is bieng developed in a technical chemical process industry, there will be a need for 975 people who may be totally unskilled. Studies

conducted by MAIN in other developing countries have shown that a major industrial complex can support a population approximately fifteen times the number of people directly employed. This employment multiplier effect arises from the need for goods and services to the facility and its employees.

Economy. This study is limited to a financial analysis of the pulp mill as it would apply to private investors. By analyzing the social opportunity costs of labor, capital and foreign exchange components, it would be possible to determine the potential benefits to the country as whole. An economic analysis is, therefore, recommended.

Size of Pulp Mill. MAIN's experience indicates that a 700 T/D pulp mill is closer to an optimum size. Revenues would be 40% greater, while the total investment would only rise approximately 22%. It is recommended that an in depth study be made to determine the optimum mill size and that a marketing study be included.

100 T/D Fiberboard Plant. As requested, the preliminary capital costs for a 100 T/D fiberboard plant have been estimated. The fiberboard plant is assumed to be part of the total operation of a new site 500 T/D pulp mill.

Laboratory and pilot scale trials and commercial operations have demonstrated the technical feasibility of manufacturing fiberboard from mixed tropical hardwoods.

A description is given of a typical fiberboard process, supplemented with a list of major equipment. Building and space requirements are shown for the plant on the overall millsite general arrangement.

Total plant investment requirements have been estimated at $19,000,000. This figure includes plant capital, startup costs, working capital, and interest during construction.

Raw materials, services, and manpower requirements are given on a data sheet for use in preparing operating costs in a future study of a specific site.

It is assumed that most of the production of a fiberboard plant would be marketed locally. Future marketing studies of a specific site are suggested to determine the market situation at that particular time and location.

A procedure is given for determining the economic feasibility of a fiberboard plant, once the selling price and market are established.

B. Impact to an Existing Pulp Mill

The use of mixed tropical hardwood for pulp wood and the substitution of wood for oil as fuel, in a steam generating boiler requires no new technology. The financial justification for conversion of an existing kraft pulp mill, however, will vary for each specific mill and location.

The first requirement is to analyze the investment costs necessary to maintain production at the existing level. Characteristics of mixed tropical hardwoods are such that more productive capacity will generally be required than for temperate zone hardwoods in the wood processing, pulp digesting, liquor evaporation, recovery boiler and liquor preparation systems. A boiler designed for mixed fuel (hog fuel and oil) will be less efficient when using larger

percentages of fuel wood. Each processing area must, therefore, be studied to determine the cost to obtain the original production when using the new pulp wood.

The potential savings should then be calculated based upon the cost difference for mixed tropical pulpwood vs. present (selectively harvested) pulpwood; and fuel wood vs. fuel oil. The cost of each of these components will be highly dependent upon the specific location selected.

Since optimization of profits is one of the goals, the information developed can be used to determine the point at which benefits from the use of mixed tropical hardwood for pulp and fuel are greatest. An example is presented in the report to show the cost savings resulting from the use of wood as fuel; and, by comparing these savings to the capital cost of a new wood fuel boiler, indicates the attractiveness of this investment. Under present market conditions, it may be desirable to accept some reduction in production to obtain the savings from the use of fuel wood.

U.S. DEPARTMENT OF AGRICULTURE
FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

INTRODUCTION

PURPOSE

The Forest Products Laboratory, in cooperation with the Agency for the International Development, is conducting research on the utilization of the secondary species in tropical forests in an attempt to assist developing nations to establish a forest products industry.

The research is aimed at promoting an industrial program to provide employment, to supply domestic and export needs, and to improve balance of trade within these nations, with consideration for ecological factors to maintain and review the forest resource. The choice of a forest products industry is based on utilization of vast natural mixed tropical hardwood forests, in view of future world demand for building products, pulp, and paper.

This study is a part of the larger program undertaken by the Forest Products Laboratory over the past several years. In that program, samples of mixed tropical hardwoods from the tropical forests of Southeast Asia, Africa, and South America have been processed and tested in the laboratory, and have been compared with products yielded from known acceptable hardwoods in North America.

The part of the study described in this report is a preliminary industrial survey of some of the present operations utilizing tropical hardwoods, and a projection based on these operations,

of the feasibility of establishing forest products industries in other areas of the world. The primary area of interest for this study was specified to be Southeast Asia. Comparisons were also to be made for Africa and South America.

SCOPE

The study is comprised of several parts. The first consideration is the harvesting of wood from the natural forest and the regeneration of the forest for continued use. The concept employed here is run-of-the-woods harvesting of secondary species, leaving an open area ecologically suitable for natural regrowth or for establishment of plantations of selected species known to grow well in the environment and to be most acceptable for use in building materials, pulp and paper.

One of the aims of the study is to describe the methods used, and to determine the economics of the harvesting and transporting of wood to a central collecting point. There, sorting will be done, and the wood sold as logs or chips, or further processed into building materials, pulp, or paper. This portion of the study was conducted by H.C. Mason & Associates, Inc.

Another aim of the study is to determine the impact of utilizing mixed tropical hardwoods in an existing pulp mill currently operating with selective tropical hardwood species. An important part of this study is the selective separation of wood for pulping, and using other species and excess wood as fuel in the boilers as a substitute for the currently used petroleum products. A section of this report describes the methods and equipment used and the economics of the projected operation as compared to the current operation.

The third request of the study is to estimate the capital and operating cost of a 500 MT/D bleached Kraft pulp mill and a 100 MT/D fibreboard mill located on a new site in a remote area of Southeast Asia. It is not within the scope of this study to evaluate a particular site. The site chosen is hypothetical and is assumed to be away from population centers. It will thus require development of the full range of infrastructure.

The mill design is described and the process, equipment, and plant layout are shown. Financial analysis of the costs is shown to evaluate the feasibility of the venture. An economic analysis is not within the scope of the study.

Pulp from the mill is to be primarily for export. The mill size was chosen for economics of scale and marketability of production, and it is assumed that output cannot be absorbed within the country selected. Fibreboard is assumed to be marketed primarily within the country.

Wood will be selectively utilized for use either in pulping, fibreboard manufacture or fuel. The new mill will use wood as the primary fuel, with oil used only for load swing requirements. It is assumed that the forest area surrounding the mill has adequate wood for all requirements.

SURVEY TRIP

In order to obtain field information for this study, trips were made to view the operation of mills using both selective species of tropical hardwood and selected mixed species of tropical hardwood. Visits were made to mills in the Phillippines and in Columbia. Discussions were also held with a paper company in Japan which is utilizing mixed tropical hardwood from an operation in Papua New Guinea.

We would like to express our appreciation to Bataan Paper Mills, Inc., Paper Industries Corporation of the Philippines, and Carton de Columbia (PULPAPEL, S.A.) for allowing us to visit their mills and especially to PICOP for additional information and help in obtaining Philippine Paper Industry statistics.

Forest operations in developing countries were also observed. Visits were made to wood operations in the Philippines, Papua New Guinea, Indonesia, Ghana, and Columbia.

OTHER INFORMATION SOURCES

A visit was also made to FAO in Rome. FAO has been involved in studies of tropical hardwood utilization for many years, and were most helpful in making a great deal of information available to us. Use has been made in this study of technical and cost information prepared by or for FAO in these previous studies.

The 1977 FAO World Pulp and Paper Consumption Outlook reports were used as the basis for the marketing of bleached hardwood sulfate kraft pulp. We would like to express our appreciation to Mr. Theodore Frey of Crown Zellerbach, a key member of the worldwide Industry Working Party, for making this information available to us.

Information generated in laboratory and pilot scale tests at the Forest Products Laboratory regarding pulping conditions and yields and pulp properties have been used in conjunction with actual mill data and other published data.

Information on pulp and paper industry activity in Brazil and their plans for pulp exports was obtained from an investment research bulletin prepared by Goldman Sachs.

Information was used also from published articles in PULP & PAPER and PULP & PAPER INTERNATIONAL.

Information obtained from the following vists was helpful in the study:

Asian Development Bank, Manila, Philippines
Philippine Board of Investments, Manila, Philippines
Honshu Paper Company, Tokyo, Japan
Mitsubishi Corporation, Tokyo, Japan
INDERENA, Bogata, Columbia

Defibrator Fiberboard AB was most kind in providing information used in the Fiberboard section of the report.

U.S. DEPARTMENT OF AGRICULTURE
FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

BACKGROUND

Utilization of tropical hardwood species for pulping and paper-making has been limited until recently, although research has been carried out for over half a century.

The general forestry practice has been to harvest the best wood selectively and to leave the secondary species standing in the forest. Operations have been established for converting these selected species into lumber and veneer, or the wood has been sold in log form for export. This selective harvesting does not allow for full utilization of the forest resource, nor does it allow for the most beneficial long term regeneration of the resource.

The concept used in this report is to employ run-of-the-woods harvesting of all species within a given forest area. The emphasis is on the utilization of secondary species for the production of pulp, with the understanding that wood value will determine the end use of more valuable species. The economics of the study by definition in the specification do not reflect the marketing of these species.

Many technical and economic studies have been conducted by FAO and others to determine the technical and economic feasibility of producing pulp and paper from tropical hardwoods. It has been generally shown in the laboratory and in mill operation that pulp can be produced using the Kraft process which is acceptable for use in selected paper grades.

Certain wood species are undesirable due to high silica content or high extractives. Some high density woods are less desirable because of the difficulty in chipping and cooking. Low density species give lower digester yield. Resin or pitch is also a problem which must be dealt with in many areas. For these reasons it is advisable to sort mixed species to cull out the undesirable wood for other purposes than pulping.

It has been reported that pulp yields are lower with tropical hardwoods than with North American hardwoods, when pulped to the same degree of delignification.

Laboratory tests have shown that tropical hardwood mixtures produce a better quality pulp than many of the individual species. The distribution of fiber dimensions and properties in the mix apparently has a synergistic effect which is beneficial to pulp properties. FPL pulp strength tests are, at a minimum, comparable with those of North American hardwoods and usually better.[1] At best, the tear factor approaches that of some long fibered pulp, after suitable beating. The power to beat to the optimum level appears to be higher for pulp from mixed tropical hardwoods (MTHW).[1]

Tests have recently been carried out at the FPL in Madison, Wiconsin to determine the problems involved in making pulp, and board from MTHW, and to compare pulp quality with that of North American hardwoods. This work confirmed earlier testing and added to the knowledge available. Wood samples from various tropical areas were successfully pulped by the Kraft and semi-chemical process. Tests of the pulps and of the papers produced indicated that the physical and optical characteristics were acceptable and comparable with similar products produced with North American hardwoods.

In the industrial survey, mills producing pulp from MTHW were visited in the Philippines and in South America. In addition

a Japanese paper company using MTHW from their own timber operation in Papua New Guinea was visited to obtain their feelings on the acceptability of the pulp.

The two mills in the Philippines are integrated and manufacture paper and board from the pulp. Grades produced and general furnishes are as follows:

Newsprint: 100% Hardwood, composed of about:
50% Kraft, 50% Refiner Mechanical Pulp

Linerboard: 80% Kraft hardwood
20% Imported softwood Kraft

Cultural Papers: 100% Hardwood (imported softwood used sparingly)

These products are sold within the country, and have standards less stringent than those established in the highly industrialized countries.

The mill in South America is integrated and produces linerboard, corrugating medium and sack paper. The approximate furnishes are:

Linerboard: 70% Kraft hardwood
30% Imported softwood Kraft

Corrugating Medium: 10% Hardwood Kraft
90% Hardwood G.L. semichemical

Sack: 80% Hardwood Kraft
20% Imported softwood Kraft

These products are sold internally with less stringent standards than standard export grades.

The Japense paper company visited uses tropical unbleached hardwood Kraft pulp in linerboard only. The furnish is approximately:

30% Softwood Kraft
30% Domestic (Japan) Hardwood
40% Tropical (Papua New Guinea) Hardwood

They said that the tropical hardwood pulp is about 15% weaker than domestic hardwood. It is now used only in blends with domestic hardwood. They indicated that the paper and board standards used in the Philippines would be unacceptable in the Japense market.

This is contrary to the results of research of the Forest Products Laboratory and others which has shown that MTHW pulp can be equal to or stronger than kraft pulps made from temperate zone hardwoods.

FAO ECONOMIC STUDIES

There have been many economic studies prepared by and for FAO. Some of these studies have presented capital and operating costs of pulp and paper mills in developing countries, and have indicated the relative profitability based on the conditions of the study. Studies have been made for mills in general areas of selected countries, without specific siting; and recently more definitive studies have been made of specific sites.

The mill capital and operating costs, and return on investment shown in this report are for a preliminary feasibility study of a mill in Southeast Asia, but not for a particular site.

[1] Mixed Tropical Hardwoods as a Raw Material for Pulp and Paper Manufacture - by the Secretariat, Food and Agriculture Organization of the United Nations, May 1976.

PROJECT NO. 1191

DECEMBER 20, 1977

MIXED TROPICAL HARDWOODS HARVESTING AND CHIP MANUFACTURING CASE STUDY FOR CHAS. T. MAIN, INC. BOSTON, MASSACHUSSETTS

PREPARED BY:

Raul Diaz

APPROVED BY:

Robert Nelson

H.C. Mason & Associates, Inc.

TABLE OF CONTENTS

	Page
PROJECT DEFINITION AND SCOPE	1
SUMMARY AND CONCLUSIONS	3
FULL UTILIZATION OF THE TROPICAL HARDWOOD RESOURCE	5
HARDWOOD CHIP MARKETS	8
GENERAL DESCRIPTION OF THE TIMBER RESOURCE	13
TIMBER HARVESTING AND TRANSPORTATION SYSTEMS	16
HIGHLAND HARVESTING SYSTEMS	17
MECHANIZED HARVESTING SYSTEM	17
LABOR INTENSIVE HARVESTING SYSTEM	17
LOWLAND HARVESTING SYSTEM	18
CHIPPING PLANT OPERATION	21
CAPITAL COST ESTIMATE	25
OPERATING COST ESTIMATE	27
INFRASTRUCTURE CONSIDERATIONS	29

TABLE OF CONTENTS (Continued)

	Page
APPENDICES	
APPENDIX 1 - GLOSSARY OF TERMS AND CONVERSION FACTORS	30
APPENDIX 2 - ANNUAL WAGE SCALE AND LABOR RATES	33
APPENDIX 3 - COST ANALYSIS: HIGHLAND MECHANIZED TIMBER HARVESTING SYSTEM	34
APPENDIX 4 - COST ANALYSIS: HIGHLAND LABOR - INTENSIVE TIMBER HARVESTING SYSTEM	42
APPENDIX 5 - COST ANALYSIS: LOWLAND TIMBER HARVESTING SYSTEM	47
APPENDIX 6 - ROADS COST ESTIMATE	53
APPENDIX 7 - TIMBER HARVESTING AND TRANSPORTATION CAPITAL AND OPERATING COST ESTIMATE	60
APPENDIX 8 - CHIPPING PLANT CAPITAL COST ESTIMATE	62
APPENDIX 9 - CHIPPING PLANT OPERATING COST ESTIMATE	66
APPENDIX 10- DRAWING: CHIPPING PLANT PLAN	70

LIST OF ILLUSTRATIONS

TABLES

1 - Price Movement of Woodchip Imports to Japan	11
2 - Log Resource Analysis	15
3 - Examples of Plant Costs in Various Regions of the World	20
4 - Plant Capital Requirements	26
5 - Timber Harvesting Annual Operating Costs Summary	27
6 - Chip Plant Annual Operating Costs Summary	28
7 - Timber Harvesting and Transportation Capital Costs	60
8 - Timber Harvesting and Transportation Annual Operating Cost	61

PROJECT DEFINITION AND SCOPE

At the request of Chas. T. Main International, Inc., Boston, Massachussets, H. C. Mason and Associates, Inc. (HCMA) of Gladstone, Oregon were invited to participate in a preliminary industrial survey or base-case study evaluating concepts for run-of-the-woods harvesting and full utilization of the tropical hardwood resource.

The overall project encompasses a broad concept of operation which include run-of-the-woods harvesting of tropical forest; design - on a preliminary engineering basis - of log handling, sorting, debarking and chip manufacturing facilities. The addition of the previously noted chip system to the operations of an existing pulp and building products mill will also be evaluated. Also considered is the utilization of chips for fuel as compared to the fuel currently being used. With the background developed from the above analysis, preliminary estimates on a totally new facility are to be prepared.

HCMA participates as a sub-contractor to Main and is in charge of the section of the report dealing with harvesting transportation and processing of the roundwood and classification of the chips.

In 1974 the U.S. Agency for International Development (AID) contracted with the Forest Products Laboratory (FPL) of the U.S. Forest Service to try to determine the technical feasibility of increasing the intensity of tropical forest utilization by exploring the possibility of using the broad range of species found in tropical forests in an integrated manufacturing scheme.

This study is part of a comprehensive series of studies that cover technical, socio-economic, ecological and silvicultural aspects of the problem.

The scope of the study undertaken by HCMA includes preliminary engineering and cost analysis of a system to harvest and transport run-of-the-woods tropical hardwoods to a processing plant and the conversion of the logs to chips of quality suitable for the manufacture of market pulp and building products, with any remainder to be used for fuel or other uses.

Capacities will be based on harvest and transport of 150,000 cubic feet (4,247 cu.m.) of round wood per day.

The chip processing plant is assumed to be at or near the product manufacturing plant or export facility calling only for delivery to their separate transport system.

Classification of chips on commercial specific gravity equipment into grades suitable for market pulp, building products, fuel and other potential uses is considered. The Forest Products Laboratory has determined that specific gravity classifiers can be used to separate the wood chips into grades before conversion into pulp and building products and as fuel for process energy. This allows full utilization of all species.

SUMMARY AND CONCLUSIONS

In the tropics, only a few logging operations practice the run-of-the-woods concept of extracting and transporting all logs available in a given area. Normally, the area is high-graded for the most valuable species and the bulk of the fiber is left in the forest. High-grading involves high operation costs and will eventually result in incomplete utilization of the raw material. The productive capacity of the forest must be improved by planting of desirable, fast-growing species, with the adoption of the run-of-the-woods concept. In addition, wood conversion systems must be modified to utilize a larger percentage of the forest biomass.

The demand for wood chips is the most rapidly expanding sector of the world forest product market. According to FAO statistics the international chips market grew from 1.3 million cubic meters (solid wood) in 1964 to 7.7 million cubic meters (same basis) in 1972. Improved technology has accelerated the use of tropical hardwoods for chip production. The world's first mixed tropical chip export project was officially opened in June 1974 at Madang, Papua New Guinea.

Timber resource data and cost figures are representative of conditions in Southeast Asia. A rotation of 50 years has been assumed for a sustained yield annual production of 1,020,000 cu. m. over a gross area of 525,000 ha. The average tree diameter is 67 cm. D.B.H. and the average height is 37 m.

For this study, it has been assumed that the daily amount of wood to be harvested is 4,245 cu. m. Three methods have been described:

1. Mechanized Harvesting System
2. Labor Intensive Harvesting System
3. Lowland Harvesting System

The average cost of delivering wood to a pulpmill site in Southeast Asia is approximately US $16.00 per cu. m. A chipping plant has been designed employing a dual system with two parallel lines. Each side is capable of processing about 90% of the required 4,245 cu. m. per day capacity of the mill. Capital costs for the Highland mechanized harvesting system used as the basis for wood costs in this study are estimated at US $43,295,040.

Chip plant capital requirements are US $8,600,000 and infrastructure cost directly related to the mill is estimated at US $1,300,000.

The cost of wood delivered to the plant site is estimated at US $15.33 per cubic meter. The cost of chips ready for the digester is estimated at US $17.30 per cubic meter.

CONCLUSIONS

1. The current harvesting practices in tropical forests are extremely wasteful. Wood chip production provides an opportunity for increased utilization.

2. The run-of-the-woods concept in tropical harvesting operations should provide competitive wood costs for chip production.

3. Demand for wood chips on the world market will steadily increase in the future. This increased demand should present opportunities for greater utilization of the tropical forest resource.

4. Cost comparisons indicate that geographic location and type of logging system used do not have a drastic effect on wood cost in the developing countries of the world.

FULL UTILIZATION OF THE TROPICAL HARDWOOD RESOURCE

There are no tropical operations, to the best of our knowledge, practicing the run-of-the-woods harvesting concept, or use a method that extracts and transports all logs obtainable. The most comon practice for utilizing tropical forests is a relatively selective process. A handful of high-value species are harvested and the rest are left standing for later use or felled and burned for shifting agriculture. Loss of residual trees is either due to size and quality restrictions or because the species left are unacceptable at the manufacturing end.

For traditional forest industries marketing up to one hundred kinds of wood, most of which are available only in very limited quantities, would constitute a formidable problem for a sales department.

One difficulty with a selective utilization system is that while its raw material cost is low its operation costs are high. Low concentration of usable material per unit of land area increase materials handling costs and the cost of delivery to conversion sites. It is inherent in such a system that relatively little of the income from the sale of products accrues to the land, most of it being required to meet the great expenses of extraction, transportation, conversion and marketing.

A second difficulty with such a system is that it can result in depletion of usable material per unit of area with the passage of time. A pattern of unregulated use of natural forests which results in the replacement of usable material by unusable material causes a reduction in the utilization efficiency of the forest production-conversion system. This has occurred, for example, in several areas of Southeast Asia where the natural forests have been high graded for the dominant dipterocarps for a long time resulting in a change of

species mix. Clearly, this mismatch between forest production and forest conversion will result in an even lower future utilization efficiency unless the forests are managed to change the species mix or unless the conversion system is changed to increase the utility of the presently less preferred species.

If there is a need to improve productivity per unit of forest land area to increase wood supply and/or accommodate a smaller forestry land base two solutions are available. The conversion system must be modified to permit it to utilize a larger fraction of the forest biomass or the forest system must be improved to minimize the production of undesirable species and residues.

If the forest production side is to be improved then forest stands need to be modified through silvicultural operations deliberately structuring the timber stands to more readily match the conversion system. Since growing wood on a managed basis is a long term process, it is reasonable to ask what assurance there is that current growing demands for wood world-wide are likely to continue. The signals are positive. Increasing shortages of nonrenewable resources are clearly going to create demands for substitution of renewable resources for nonrenewable resources for industrial materials. The level of management required to achieve an improvement in stand composition would be justified only if there is a compelling need to increase production of wood to satisfy domestic requirements and/or a desire to share in the opportunities represented by the growing world market for wood.

Modification of the conversion system to increase per unit of area utilization

efficiency usually involves the introduction of processes that are relatively indiscriminate with respect to species and quality. Normally these are such installations as pulp mills, fiberboard plants or particleboard plants which are capital intensive installations that are relatively low in labor utilization. Furthermore, for many of these processes, products from long fibre coniferous woods have structural advantages. There are some other options of course such as charcoal, a conversion industry that formerly was important, may be recovering in the climate of the unavailability of fossil fuels and it has the indiscriminate quality required. World markets for chips have been strong until relatively recently and this conversion requires considerably less capital investment than going on to the pulp stage.

HARDWOOD CHIP MARKETS

The most rapidly expanding of the world forest product markets is that for wood chips. Until the recent economic slump the world market for chips for fiber production exhibited a very high growth rate and there is every reason to expect that this growth will be resumed soon. Chips are shipped for thousands of miles hence the chip market is no longer reserved for the forest that happens to be located near a pulp mill. Chips and flakes and other forms of wood particle are increasingly in demand for the production of panel products. Improved technology that permits greater use of hardwoods for fiber production is of similar significance.

The most impressive volume of under-utilized wood is in the tropical broad-leaved forests of the developing regions. These comprise half of the world's wood volume Not only are there large parts of these regions with more difficult accessibility such as much of the Amazon and Congo interiors, but, perhaps more important, there are usually large portions of the wood volume in forests already exploited, or being exploited, which are left uncut. A major problem in utilizing this material for pulping has been the wide range of wood species which occur in any limited forest area. However, there are already a few cases of successful pulp production from selected mixed tropical hardwoods. Furthermore, during the last five years there have been remarkable advances in pulp and paper technology, including the recent research on pulping mixed tropical species carried out by the Forest Products Laboratory, Madison, Wisconsin. There is now abundant evidence that tropical species may be utilized, in mixture, for the production of the widest range of papers.

The problems of pulp and paper development in tropical countries are not technological, but are essentially confined to capital formation and the

availability of trained personnel and the costly basic infrastructure required by this industry.

In 1974 the developing countries possessed only 6.2% of the world's capacity to produce pulp and paper.

Utilization of the mixed tropical species fiber source will likely be initially directed primarily to domestic demand. Often utilizing the mixed tropical forest may be a transitionary stage in shifting to plantations as the primary fiber source. This trend is very obvious in Southeast Asia and Latin America (Philippines, Papua New Guinea, Indonesia, Brazil).

Tasmania has emerged as one of the world's most important sources of wood chips, especially eucalyptus. A chip mill on the Tamar River in Northern Tasmania, belonging to Associated Pulp and Paper Mills Ltd., will be shipping 900,000 tons annually to Japan. The capital investment in this modern chip plant and the port, including all handling equipment, is reported to amount to 14 million Australian dollars.

Other important wood chip contracts: In 1970 the Japanese and the Russians negotiated a contract for the supply of a total of 3.65 million cubic meters of softwood and hardwood chips in six years. The prices, although not disclosed, are reportedly based on the international levels. Chips of rubber-tree wood wastes from sawmill and plywood mills in West Malaysia are shipped to Japan and Formosa.

The first transocean shipment of wood chips was made in 1964 from Oregon to Japan. By 1967 Japan imported 1.4 solid million cubic meters of wood chips, almost entirely from the USA.

Table 1 shows the quantity and average value of chips exported from the West coast of USA, Russia, Canada and New Zealand to Japan. Most of the chips are from softwoods. Some whole-tree chips from alder were exported in 1974 but this ceased in 1975.

The change in the type of raw material used for pulping has been noticeable in Japan. In 1950, no hardwood was used as pulpwood in Japan, but by 1971 hardwood and softwood were being consumed in the ratio of 60 to 40. At the same time, chips have been replacing logs as the raw material delivered to the pulp mill. The ratio of chips to logs reached 75 to 25 in 1971.

Japan, thus appears as the world's main buyer of chips. Recently, long term chip contracts have developed between Sweden and Southeastern USA. U. S. Southern pine chips will dominate the trade as hardwood chips are difficult to market in Europe. The CIF price was about US $80 per bone dry metric ton for deliveries in 1975 and 1976.

As mentioned above most of the world's chip markets are for softwood chips. The world's first mixed tropical chip export project was officially opened in June 1974 at Madang, Papua, New Guinea.

Japanese consumption of paper has increased at an average rate of 9% over the last decade. This situation has placed a great strain on Japan's domestic forest resources. The trend has been towards the greater use of hardwoods for pulp and to increasing imports of chips. The hardwood chip contracts mentioned above are concerned with single species or groups of similar species. The Papua, New Guinea operation is the only true mixed tropical chip export. operation in the world.

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TABLE 1

Price Movement of Woodchip Imports to Japan, 1970-75
(Quantity=000 tons; Value=$000 c.i.f., Unit Value=US$/ton)

Year	U. S. A.			U. S. S. R.			CANADA			NEW ZEALAND		
	Quantity	Value	Unit Value	Quantity	Value	Unit Value	Quantity	Value	Unit Value	Quantity	Value	Unit Value
1970												
Jan.-Jun.	1,477	n.a.	n.a.	-	-	-	-	-	-	83.3	n.a.	n.a.
Jul.-Dec.	1,839	n.a.	n.a.	-	-	-	10.8	306	28.3	89.2	n.a.	n.a.
Total	3,316	81,940	24.7	-	-	-	10.8	306	28.3	172.5	3,690	21.4
1971												
Jan.-Jun.	1,194	49,243	41.2	-	-	-	5.3	312	58.9	38.8	1,906	49.1
Jul.-Dec.	699	27,443	39.2	-	-	-	224.8	10,109	45.0	46.5	2,340	50.3
Total	1,893	76,686	40.5	-	-	-	230.1	10,421	45.3	85.3	4,246	49.8
1972												
Jan.-Jun.	1,232	46,227	37.5	1.6	73	45.6	82.2	3,083	37.5	54.9	2,625	47.8
Jul.-Dec.	1,374	54,833	39.9	13.5	570	42.2	4.5	193	42.9	63.5	3,087	48.6
Total	2,606	101,060	38.8	15.1	643	42.6	86.7	3,276	37.8	118.4	5,712	48.2
1973												
Jan.-Jun.	1,715	64,173	37.4	17.2	577	33.5	-	-	-	77.8	3,636	46.7
Jul.-Dec.	2,032	79,003	38.9	24.0	827	34.4	-	-	-	63.4	3,055	48.2
Total	3,748	143,176	38.2	41.2	1,404	34.1	-	-	-	141.2	6,691	47.4
1974												
Jan.-Jun.	2,196	101,060	46.0	48.6	2,039	41.9	-	-	-	68.4	3,981	58.2
Jul.-Dec.	1,872	125,863	67.2	67.5	3,275	48.5	-	-	-	92.6	6,222	67.2
Total	4,068	226,923	55.8	116.2	5,314	45.7	-	-	-	161.0	10,203	63.4
1975												
Jan.-Jun.	1,538	117,393	76.3	91.3	4,253	46.6	-	-	-	72.5	5,452	75.2
Jul.-Dec.	1,840	142,780	77.6	94.8	4,543	47.9	-	-	-	88.3	6,867	77.8
Total	3,378	260,173	77.0	186.0	8,796	47.3	-	-	-	160.8	12,319	76.6

Notes: 1. Totals may not add due to rounding.
2. Tons are assumed to be long tons, but source is unclear.
3. Values converted from Yen at 300=US$1.00.

Source: Japan Lumber Journal, 1976.

As mentioned before this interest in mixed tropical species appears to be transitory. The Japanese pulp industry has expressed great interest in the potential of plantation grown Kamarere (Eucalyptus deglupta) and Albizia falcataria as a source of pulp chips in tropical areas.

GENERAL DESCRIPTION OF THE TIMBER RESOURCE

All figures used in this tropical timber operation study, as well as forestry and socio-economic factors were selected to be representative of Southeast Asian conditions.

An all pulpwood forest of 150 cu. m. of solid pulpwood per hectare is envisioned. It is assumed that saw logs and veneer peeler blocks, if available, are to be used for such purposes, though no extraction cost has been allotted to such products and no revenue from their sale or processing is considered.

A rotation of 50 years is assumed sufficient to obtain a yield of 150 cu. m. per hectare. For a sustained yield of 36,000,000 cu. ft. (1,020,000 cu. m.) per year, 340,000 ha of tropical forest are needed. Considering that roads, rivers, swamps, agriculture land and marginal forest land accrue for 35% of the area, the total area involved will amount to 525,000 ha. If the chipping plant is located close to the center of this area a maximum transportation distance of 50 km. and an average transportation distance of 35 km. may be assumed.

The average diameter of the trees is 26.5 inches d.b.h. (67.3 cm.) and the average height of the dominant trees is 120 feet (37 m.). The log resource is summarized in Table 2. The average log diameter and length after bucking are 20 inches (50.8 cm.) and 16 feet (4.88 m.) respectively with an average volume of 45.35 cu. ft. (1.284 cu. m.).

The average log length and volume before bucking are 241 cu. ft. (7.32 m.) and 68.02 cu. ft. (1.926 cu. m.) respectively.

The topgraphy within the project area is assumed to be 60% average and 40% difficult. The average annual temperature is approximately 84° F. and rainfall is about 100 inches per year. Rain occurs in every month of the year with a two month "rainy" season with precipitation of 15 to 20 inches each month.

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TABLE 2 - LOG RESOURCE ANALYSIS

Diameter (In.)	Number of Logs Per Day	Log (%) Distribution	Number of Logs Per Min. *	Final Footage Per Minute (ft./min.)	Vol. Per Log (cu. ft.) **	Vol. Per Minute (cu. ft./min.)
8	33.1	1	.046	.736	8.6	.396
10	99.2	3	.138	2.208	12.5	1.725
12	231.5	7	.322	5.152	17.3	5.571
14	396.9	12	.551	8.816	22.6	12.453
16	463.1	14	.643	10.288	28.7	18.454
18	562.3	17	.781	12.496	35.6	27.804
20	396.9	12	.551	8.816	43.1	23.748
22	330.8	10	.459	7.344	51.3	23.547
24	264.6	8	.368	5.888	60.3	22.190
26	165.4	5	.230	3.680	70.1	16.123
28	99.2	3	.138	2.208	80.6	11.123
30	66.2	2	.092	1.472	91.7	8.436
32	66.2	2	.092	1.472	103.7	9.540
34	33.1	1	.046	.736	116.3	5.350
36	33.1	1	.046	.736	129.7	5.966
38 and over	66.2	2	.092	1.472	174.0	16.008
Total -	3,307.8	100	4.60	73.520	-	208.434
Average 20					45.35	

* Two 8 hour shifts per day; effective processing time = 75% of clock time or 360 minutes per shift. (for chipping plant)

** Average log length after bucking 16'

TIMBER HARVESTING AND TRANSPORTATION SYSTEMS

In this section the selection of a harvesting system to remove 150,000 cu. ft. (4,245 cu. m.) of timber to supply a pulpmill with mixed tropical species is discussed.

Timber harvesting in tropical areas takes many forms according to local conditions. Existence of water ways, timber sizes, topography, climatic conditions, salary levels, equipment and parts availability, labor availability, local customs, etc., play an important role in the form and method of harvesting.

An extensive trip visiting logging operations in tropical regions of the world was made. Operations in The Philippines, Indonesia, Papua New Guinea, Ghana, Colombia and Brazil were visited. Cost data was collected and cost studies performed for different systems in different tropical regions of the world. These costs were compared with other published logging costs (see Table 3). The cost studies and comparisons show that geographic location and type of logging system used do not have a drastic effect on cost in the developing regions of the world.

Three different logging cost studies are included. They were selected based on their flexibility of application as well as to compare mechanized versus labor intensive operations and wetland versus highland conditions.

A. HIGHLAND HARVESTING SYSTEMS

A - 1. MECHANIZED HARVESTING SYSTEM

Felling is accomplished by means of a two man power saw crew who fall, limb and buck the top of each tree. Production is estimated at 2,500 cu. ft. (70 cu. m.) per day per crew once they have been trained and acquired some experience. A foreman should supervise six crews; 60 crews are required.

Skidding is estimated also at 2,500 cu. ft. (70 cu. m.) per day per crawler tractor, using conventional wire rope chokers and fair lead winch arrangement. A skidding crew consists of an operator and two choker men. Sixty crews are required.

Thirteen loaders, at 12,000 cu. ft. (340 cu. m.) per loader per day, are required to load the 150,000 cu. ft. per day by requirement. Each loading crew consists of an operator and one landing helper.

Log hauling is performed with 38 trucks bringing four loads or 16,000 cu. ft. (450 cu. m.) per day each. The average hauling distance is 35 kilometers to the chip plant. Direct manpower for this phase of the operation includes 38 truck drivers.

Total direct manpower amounts to 580 people.

A - 2. LABOR INTENSIVE HARVESTING SYSTEM

Felling, log bucking, debarking, splitting and piling is accomplished by means of an eight man crew. Production is estimated at 1,240 cu. ft. (35 cu. m.) per day per crew. One hundred and twenty-one crews are required.

A cable system is used to forward short-wood bundles to roadside. Forwarding is estimated at 1,415 cu. ft. (40 cu. m.) per day per 7 man crew. A foreman supervises two crews; 106 cable crews are required.

Trucks are loaded by hand. Loading is estimated at 1,000 cu. ft. (28 cu. m.) per crew per day. One hundred and fifty crews are required.

Seventy-five trucks at four loads a day or 2,000 cu. ft. (57 cu. m.) per truck per day transport the 150,000 cu. ft. (4,250 cu. m.) daily requirement.

Total direct manpower amounts to over 1,800 people.

B. LOWLAND HARVESTING SYSTEM

The timber harvesting operation is performed as described in A - 2. by crews of 8 people. Felling of the tree is done by power saw or axe, then the tree is bucked by the power saw into logs, one meter long. These logs are peeled and the large ones are split for manual transportation to lines where a cable system will extract them in bundles to a landing.

The extraction cable system winch is mounted on a flat bottom barge, which winches itself along through the woods to the setting. Short log bundles are then lifted out to landings.

In the landings the wood is loaded by a cherry picker loader onto 250 ton flat bottom barges which are then towed to the mill site.

The system above described accounts for pulpwood in short length form. A similar system with slight variations for bucking and skidding (cable system

also) operations is assumed to deliver sawlogs and veneerlogs at the same cost per unit of volume.

The logging and transportation system described is applicable in the fresh water flooded areas located immediately inland from the coastal mangrove formations or in the mangrove forests themselves.

Total direct manpower amounts to over 1,800 people.

TABLE 3 - EXAMPLES OF PLANT COSTS IN VARIOUS REGIONS OF THE WORLD

PULPWOOD (SEPTEMBER 1977)

Region	US $ / Cu. M.
United States	
- Southeast 1/	10.10 - 12.40
- Pacific Coast 1/	14.40 - 17.50
Scandinavia 1/	27.60 - 29.90
East Africa 1/	9.30 - 12.40
West Africa 2/	18.20
Brazil 1/	11.70
Southeast Asia 1/	11.30 - 16.40
- Philippines 3/	17.00
- Indonesia (Borneo, Highland) 3/	20.00
- Indonesia (Sumatra, Lowland) 3/	12.00
- Papua New Guinea (Highland) 3/	17.60
South America	
- Colombia 1/	17.90 - 21.00
- Colombia Highland 3/	18.50
- Colombia Lowland 3/	15.00
- Brazil Lowland 3/	14.00
Typical Conditions	
- Highland mechanized 4/	17.10
- Highland labor-intensive 5/	18.30
- Lowland 6/	15.30

1/ CIDA Pulp and Paper Study - Colombia; Tables 3-20 page 40 adjusted for inflation from January 1975 to September 1977 is 10%.

2/ Greenacres Consulting Co. Ghana on Opportunity for a Pulp and Paper Industry. Table 9 page 37, adjusted for inflation.

3/ H. C. M. A. Timber Harvesting Cost Studies. 1977.

4/ Appendix

5/ Appendix

6/ Appendix

CHIPPING PLANT OPERATION

Upon arrival at the chipping plant, log trucks proceed through a scaling station. Scaling is performed by one man who accounts for the daily truck tally. This function is two-fold; to maintain a log production inventory and in case of contract truckers or direct supplier delivery, to form the basis for payment.

From the scales the truck proceeds to a log washing station. After a full load has been washed the logs are unloaded and placed either in the log storage yard or onto one of the infeed decks of the chipping plant. The log storage area and yard is covered with a two foot rock fill to provide all weather usage. There is sufficient log storage to hold up to an equivalent of 2,250,000 cu. ft. (63,700 cu. m.) of solid wood or 15 days roundwood supply when piled five to six meters high.

Logs are moved along the infeed deck by chains with the aid of a 15 ton log crane to unscramble logs, transfer oversized logs to the large log mill side or to remove unsuitable logs from the system.

The chipping plant (see plan appendix) is basically a dual system with two parallel lines. Each side is capable of processing about 90% of the required 150,000 cu. ft. per day processing capacity. The reason for this design is to enable the chip plant to supply the pulpmill without costly interruptions. With one line down the chip plant is able to supply the pulp mill almost without requiring working a third shift. This depending primarily on the size of the log processed.

The small log side can process logs up to 35" in diameter. According to

the resource description (see Table 2) this line will process over 70% of the volume. To prevent down time this ring debarker has one complete spare tool assembly on a track to allow tool repair on one set while the other set is being used.

The large log side has a 50" ring debarker with four hydraulic pressure control tools and a log break down system for logs above the 34" opening on the chipper. The log break down system includes a log deck, a three block carriage with electric set works and a dual arbor circle saw to quarter logs up to 50" diameter to a cross section to fit the 34" opening in the chippers. The rollcase conveyor outfeed from the barker is reversing and has kickers to provide a return system for quartering the logs.

Both barkers are mechanical ring barkers equipped with variable feed rate drive and air operated controllable tool pressure to permit the operator to adjust the barking conditions to the log being processed. The barkers have the capacity to process logs at a lineal footage rate of up to 150 feet per minute. The barker ring rotation speed provides tool coverage at 225 feet per minute so that at slower speeds the tools would pass over the log three or four times. Hydraulic barkers were also considered but for environmental and processing efficiency considerations mechanical ring barkers were selected. Furthermore, the wet bark would have been an unsuitable fuel for the power plant.

The barker outfeed conveyor and the chipper infeed conveyor are so arranged, with an 18" difference in elevation, that logs from the barker can ride over a small log being fed to the chipper. This feature permits, when running smaller logs, operation of the barker at a faster rate than the infeed rate

to the chipper. When this happens two logs will simultaneously be fed to the chipper. When processing smaller logs the production rate is maintained at a high level by this means.

Debarked logs are conveyed to either one of two identical 34" V-drum chippers with five knives each. The drums rotate at 300 RPM to produce 3/4" long chips. Each chipper is driven by a 1,500 HP motor. The feed rate of the chipper is 112 F.P.M.

The chipper knives are sharpened on a standard knife grinder provided with jigs to simplify training requirements. Babbited backing for each unit to standardized knife length before grinding is recommended. This permits the installation of the knife into the chipper unit without any adjustment, thereby simplifying knife changing. Changing is expected to be required every four hours. This operation requires approximately fifteen minutes. As mentioned before the excess capacity considered at design makes possible to change knives during the normal shift operation hours.

The filing room is also provided with circle saw sharpening equipment consisting of shop tools for sharpening and benching, and a portable grinder for saw touch-up sharpening.

Chips flow through a surge control system onto a 48" belt conveyor to a conventional screen room.

Overs and bark are conveyed to a roto disc screen and hammer mill to reduce them to a usable size for hog fuel. Residues are conveyed on a 24" belt to the fuel pile.

Provision has been made to collect the fines for possible particleboard use.

Chips are stored in an open storage pile. As specified in the scope of work an air floatation system for specific gravity separation of chips into grades suitable for market pulp was to be considered. From the HCMA preliminary engineering design a commercial installation of this sort seemed to be inadvisable due to energy consumption and capital expenditure considerations. Equipment manufacturers, the U. S. Forest Service Engineering Laboratory at Houghton, Michigan, and the U. S. Forest Service Products Laboratory were also consulted. At the same time the alternative of manual log segregation and standing tree species discrimination were analyzed.

Manual selection is recommended taking into consideration the following technical and socio-economic factors:

1. No commercial chip air separation system has ever been built.

2. For effective specific gravity discrimination chips should be dried prior to separation. This is a complex and energy consuming task which will deliver unwanted dried chips for pulping.

3. The drying and air separation equipment involves a substantial capital expenditure (over 3 million dollars according to the preliminary design study) amounting to over 35% of the total capital expenditure of the mill.

4. The additional chip processing cost would make the pulp mill raw material cost substantially higher.

5. A non commercially proven capital intensive process is not the most advisable suggestion in a project to be implemented in a developing country.

CAPITAL COST ESTIMATE

All capital cost estimates are based on an annual production of 36,000,000 cu. ft. (1,020,000 cu. m.) of solid wood or 150,000 cu. ft. (4,247 cu. m.) per day considering 240 working days per year.

Capital costs have been estimated for each of the three mixed tropical hardwood timber harvesting systems as follows:

Highland Mechanized	US $43,295,040
Highland Labor Intensive	US $37,795,140
Lowland System	US $20,613,740

Annual allowances for depreciation, interest and insurance are as follows:

	U. S. DOLLARS		
	Depreciation	Interest	Insurance
Highland Mechanized	5,581,500	3,022,870	457,350
Highland Labor Intensive	4,604,740	2,558,970	341,400
Lowland System	3,391,300	2,199,970	390,940

Details of these estimates are in Appendix 7.

For the lowland harvesting and transportation system no road system has been considered based upon the assumption that 100% of the log transportation can be done by water. There are many areas in the tropical regions of the world where the river systems can be used for rafting or barging of logs to the mill; extensive areas in the Brazilian Amazon, Southwest Colombia, Surinam, French Ghana and Indonesia, visited during the study trip, can be classified in this category. In many other areas complementary roads may be contemplated.

In this latter case allowance has to be made for multiple loading and unloading of logs at the transportation system transfer points.

Over 70% of the tropical forests of the world can be classified as being part of the highland category. The road systems required in these highland forests for continuous and reliable delivery of roundwood to a mill, amounts to almost one third of the capital required for the roundwood extraction operation. Areas with existing access roads result in substantial capital savings.

Below is a summary of the capital requirements for the chipping plant:

TABLE 4 - PLANT CAPITAL REQUIREMENTS

ITEM	VALUE US DOLLARS
1,000 - Site Preparation	200,000
2,000 - Foundations	400,000
3,000 - Buildings	200,000
4,000 - Utilities	1,180,000
5,000 - Machinery	5,664,000
6,000 - Equipment	250,000
7,000 - Design & Engineering	350,000
8,000 - Contingency	356,000
Total	8,600,000
Infrastructure	1,300,000
GRAND TOTAL	$9,900,000

OPERATING COST ESTIMATE

Appendices 3 to 7 detail the Harvesting and Road Cost Analysis. Table 5, below, presents a total Operating Cost Summary:

TABLE 5 - TIMBER HARVESTING ANNUAL OPERATING COSTS SUMMARY

ITEM	HIGHLAND MECHANIZED SYSTEM US $	HIGHLAND LABOR-INTENSIVE SYSTEM US $	LOWLAND SYSTEM US $
Variable Costs			
Timber Royalties	510,000	510,000	510,000
Manpower Cost	1,486,280	5,911,880	5,191,155
Maintenance, Supplies, and other Variable Costs	6,979,680	5,167,180	4,325,900
Total Variable Costs	8,975,960	11,599,060	10,527,055
Fixed Costs			
Depreciation	5,581,500	4,604,740	3,391,300
Interest	3,022,870	2,558,970	2,199,970
Insurance	457,350	341,400	390,940
Total Fixed Costs	9,061,720	7,505,110	5,982,210
Grand Total	18,537,680	19,104,170	16,009,265

The mechanized system is less costly for the Southeast Asia Highland Operation being considered. The Lowland Harvesting System shows the effect of local variables; in this case, the effect of existing water ways on delivered wood cost.

The cost difference between mechanized and labor intensive is not big enough to make generalizations. Local conditions such as labor rates, fringe benefits,local taxes, customs duties, etc., may have marked effect on operating cost.

Labor intensive systems may be desirable from a social point of view in certain cases but the difficulties of a steady supply of roundwood with a large contingent of labor may be difficult to achieve in practice.

Details of the Chip Plant Operating Costs are in Appendix 9. Table 6 below presents the cost estimate summary.

TABLE 6 - CHIP PLANT ANNUAL OPERATING COSTS SUMMARY

ITEM	US DOLLARS
Variable Costs	
Labor	142,270
Overhead	178,500
Power Cost	644,540
Maintenance and Supplies	1,200,000
Total Variable Cost	2,165,310
Fixed Costs	
Plant Depreciation, Interest and Insurance	1,574,000
Other Infrastructure	172,900
Total Fixed Costs	1,746,900
Grand Total	3,912,210

In the above cost analysis no allowances have been made for taxes.

INFRASTRUCTURE CONSIDERATIONS

The chip plant is assumed to be located immediately adjacent to the pulpmill. Thus, no cost has been considered for special storage and shipping facilities. Infrastructure cost directly related to the mill (expatriate or staff housing and necessary utility connections) are estimated at $1,300,000. General purpose infrastructure considerations are discussed in the pulpmill study section.

For the woodlands operation the infrastructure considered is broader and more extensive than the cost analysis shows in Appendix 8. Woodland operations generally need extensive infrastructure development and the tropical regions are no exception to this rule. Depending upon the case it may be necessary to provide housing to all workers. The cost studies include limited housing facilities building. The housing problem becomes critical when a labor intensive harvesting system is established in remote areas.

APPENDIX 1

GLOSSARY OF TERMS AND CONVERSION FACTORS

APPENDIX 1 - GLOSSARY OF TERMS AND CONVERSION FACTORS

Barker	A machine that removes the bark from a log.
Barker ring	See ring barker
Buck	To saw felled trees or logs into shorter cuts.
Cable	A wire rope of great tensile strength.
Cable systems	A loose term for any system involving transport along and/or by means of steel cables, the load being lifted partially or wholly off the ground.
Carriage	A frame on which are mounted the head blocks, set works and other mechanisms for holding a log while it is being sawed, and also for advancing the log towards the saw line after a cut has been made. The carriage form is mounted on trucks which travel on tracks, the carriage being actuated by a steam feed, or electric carriage drive, which propels it back and forth past the head saw.
Carriage knee	The vertical portion of the head block against which the log or cant is positioned by the carriage dogs.
Carriage set works	The mechanism on a log carrage which serves to advance the knees towards, or withdraw them from, the saw line, so regulating the thickness of the piece being cut.
Centimeter (cm.)	One hundredth of a meter. (2.54 cm. = 1.0 inch)
Cherry picker	Hydraulic boom crane of light capacity.
Chipper	A machine which makes chips.
Chips	Small pieces of wood chipped off e.g. a log billet or block by axe-like cuts as in a chipper of the paper industry.
Choker	A noose of steel cable or a loop of chain that is tightened around a log and terminates in a hook or other fastening device, used for handling logs.
Clear cutting	To cut all trees in a stand of timber.
Cubic foot (cu. ft.)	A block 12 inches by 12 inches by 12 inches.
Cubic meter (cu. m.)	35.315 cubic feet.

D.B.H.	Diameter at breast height (4.5 feet above ground level)
Dual arbor circle saws	A sawmill with two arbors, one mounted above the other, each with its own circular saw.
Faller	Member of a timber-felling crew.
F.P.M.	Feet per minute.
Hardwood	A conventional term for the timber of broadleaved trees, and the trees themselves, as distinguished from softwoods.
Hectare	A unit of area in the metric system which equals 10,000 square meters (2.471 acres).
Hog	A machine for reducing wood or bark to coarse chips.
Horse power (HP)	A unit of power equal to 746 watts.
Infeed conveyor	a conveyor which feeds a machine doing manufacturing work.
Kilometer	A metric unit of measurement which equals 1,000 meters.
Log deck	The platform in a mill upon which the logs are collected and stored.
Log kicker	Cylinder operated punch bars which throw logs out of log conveyors or slips.
Log washer	A device with water jets which remove rocks and other debris from a log before it enters a barker or saws.
Meter (m.)	The basic metric unit of length. Equal to 39.37 inches.
Outfeed conveyor	A conveyor which carries material away from the output side of a machine.
Overs	Oversize chips which exceed the accepted size of marketable chips.
Roll cases	A framework upon which is mounted rolls and which is used to transport lumber lengthwise.
R.P.M.	Revolutions per minute.
Screen	A device used to separate different sizes of materials with motion of the machine.

Tally, log	A record of the volume of logs estimated by log rule.
Yield, sustained	As applied to policy method, or plan of forest management, implies continuous production with the aim of achieving, at the earliest practical time, an approximate balance between net growth and harvest.

APPENDIX 2

ANNUAL WAGE SCALE AND LABOR RATES

APPENDIX 2 - ANNUAL WAGE SCALE AND LABOR RATES

Salaried	Base	Fringe	Total
A. General Manager	$40,000	50%	$60,000
B. Managers	35,000	50	52,500
C. Superintendents	14,000	50	21,000
D. Supervisory	8,000	50	12,000
E. Secretarial	4,000	50	6,000
F. Clerical	4,000	50	6,000

	Base Hourly Rate	Base Annual (2080 Hrs.)	Fringe	Total Annual (2080 Hrs.)	Total Hourly Rate
1. Labor Minimum	$ .80	$ 1664	30%	$ 2163.	$ 1.04
2. Semi Skilled	1.20	2496	30	3245.	1.56
3. Skilled	1.60	3328	30	4326.	2.08
4. Technician	2.00	4160	30	5408.	2.60
5. Mechanical	2.60	5408	30	7030	3.38

APPENDIX 3

COST ANALYSIS: HIGHLAND MECHANIZED TIMBER HARVESTING SYSTEM

APPENDIX 3 - COST ANALYSIS: HIGHLAND MECHANIZED TIMBER HARVESTING SYSTEM

VARIABLE COST SUMMARY

Item	Pulpwood - $/Cu.M.	Fuelwood - $/Cu.M.
Felling	0.41	0.41
Skidding	6.99	6.99
Loading	1.35	1.35
Hauling	3.08	3.08
Crew Transportation	0.14	0.14
Temporary Roads 1/	1.33	
Permanent Roads Maint. 1/	0.65	
Overhead	0.30	
Other Miscellaneous	0.58	
Timber Royalty	0.50	
Total Harvest	15.33	11.97
Chip Conversion	1.97	1.58
Total Chip Cost	17.30	13.55

1/ See Appendix 6.

Felling

Production

1 Two-man crew	2,500 cu. ft./day
60 Two-man crews	150,000 cu. ft./day

Equipment Cost

1.4	Power saws @ 320	$450
10	Axes @ 10	100
10	Files @ 2	20
	Power saw filing equipment	50
	Parts and Maintenance	100
		$720

Depreciation 1 year	$720
Interest 12%	86
Maintenance and Supplies @ 15%	108
	$914

Labor Cost

1 Power saw operator	$3,245
1 Laborer	2,163
1/6 Foreman @ 4,326	721
	$6,129

Annual Crew Cost	$7,043
Daily Crew Cost	$29.34
Unit Cost	$0.01 per cu. ft. $0.41 per cu. m.

Skidding

Production

1 "Skidding Crew" 2500 cu. ft./day

60 Skidding Crews 150,000 cu. ft./day

Equipment Cost

1.4 D7 Crawler tractor with blade @ 160,000	$224,000	
Spare parts, tools, etc.	48,000	
	$272,000	
Depreciation (90% in 5 years)		$ 40,320
Maintenance and Repairs @ 15%		33,600
Interest 12% over ave. investment		19,584
Insurance 2%		4,480
Fuel and Supplies (8 gals./hr. @ $0.50 + 2%)		12,160
		$110,114

Labor Cost

1 Tractor operator		$4,326
2 Choker men	@ $2,163	4,326
		$8,652

Annual Cost $118,796

Daily Cost $494.98

Unit Cost $ 0.20 per cu. ft.
6.99 per cu. m.

Loading

Production

1 loader @ 800 cu. ft. solid wood per load

15 loads a day 12,000 cu. ft./day

13 loader 150.000 cu. ft./day

Equipment Cost

1.4 loader @ 158,700	$222,180	
Spare parts and tools	40,000	
	$262,180	
Depreciation (90% in 5 years)		$ 39,992
Maintenance and Repairs (15%)		33,327
Interest 12%		18,876
Insurance 2%		4,450
Fuel and Supplies (5 gals./hr. @ 0.50 + 1%)		7,000
		$103,645

Labor Cost

1 Operator	$ 4,326
1 Laborer	2,163
	$ 6,489

Annual Cost $110,134

Daily Cost $458.89

Unit Cost $ 0.04 per cu. ft.
1.35 per cu. m.

Hauling

Production

1 truck 4 loads per day = 4000 cu. ft./day

38 trucks 152,000 cu. ft./day

Equipment Cost

1.4 trucks @ 110,000	$154,000	
Spare parts and tools	35,000	
	$189,000	
Depreciation (90% in 5 years)		$ 27,700
Maintenance and repairs @15%		23,100
Interest 12%		13,600
Insurance 2%		3,100
Fuel and Supplies (@ 0.20 per km; 60,000 km/year)		12,000
		$ 79,500

Labor Cost

1 truck driver	$ 4,326
Annual Cost	83,826

Daily Cost $ 349.28

Unit Cost $ 0.09 per cu. ft.
3.08 per cu. m.

Crew Transportation

Production 36,000.000 cu. ft.

Manpower

Felling	130
Skidding	180
Loading	26
	336 people

12 "30 passenger buses"

Equipment Cost

1.4 * 12 buses @ $25,000	$420,000	
Spare and parts	62,500	
	$482,500	
Depreciation (90% in 5 years)		$ 75,600
Maintenance and repairs @ 15%		63,000
Interest 12%		30,250
Insurance 2%		8,400
Fuel and Supplies ($0.20 per km; 60 km per day, 240 days x 12)		34,560
		$211,810

Labor Cost

12 bus drivers @ $3,245	$ 38,940

Annual Cost $250,750

Unit Cost $0.007 per cu. ft.
$0.24 per cu. m.

Overhead

Production 36,000,000 cu. ft.

Costs:

Resident Manager (50% cost t wood procurement)	$ 30,000
Logging Manager	52,500
Transportation Superintendent	21,000
Logging Superintendent	21,000
Maintenance Superintendent	21,000
Supervisors (8) @$12,000	96,000
Administration	
3 Secretaries @$6,000	18,000
6 Clerical @$6,000	36,000
General Services Personnel (5) @$3,245	16,225
Annual Cost	$ 311.725

Unit Cost $0.01 per cu. ft.
$0.30 per cu. m.

Other Infrastructure Costs

Production 36,000,000 cu. ft.

Costs:

25 Jeep Wagons @ $9,000	$225,000	
Spare and parts	34,000	
	$259,000	
Depreciation (90% in 3 years)		$ 67,500
Maintenance and Repairs @15%		33,750
Interest 12%		20,720
Insurance 2%		4,500
Fuel and Supplies (40,000 km * year *$.15 x 25 units)		150,000
		$276,470

Expatriate personnel housing and utilities		
10 houses @ $75,000	$750,000	
Depreciation (90% in 10 years)		$ 67,000
Interest 12%		49,500
Maintenance 5%		37,500
Utilities ($200 per mo. * 12 * 10)		24,000
		$178,000
Office Space and Utilities		100,000
Technical Equipment		20,000
Annual Cost		$574,470

Unit Cost $.016 per cu. ft.

$.56 per cu. m.

APPENDIX 4

COST ANALYSIS: HIGHLAND LABOR - INTENSIVE TIMBER HARVESTING SYSTEM

APPENDIX 4 - COST ANALYSIS: HIGHLAND LABOR INTENSIVE TIMBER HARVESTING SYSTEM

COST SUMMARY

ITEM	$ per cu. ft.	$ per cu. m.
Variable Costs		
Fell, buck, debark, split, pile	0.07	2.56
Forward to roadside	0.18	6.19
Loading	0.018	0.64
Hauling	0.11	3.91
Crew Transportation	0.035	1.24
Road Maintenance	0.02	0.65
Total Variable Cost	0.433	15.19
Fixed Costs		
Overhead	0.01	0.30
Permanent roads	0.06	2.27
Other infrastructure	0.016	0.56
Total Fixed Cost		
Grand Total	0.519	18.32

Fell - Buck - Debark · Split - Carry - Pile

Production

One 8 - man crew	1,240 cu. ft./day
121 8 - man crews	150,040 cu. ft./day

Equipment Cost

1.4	Power saw @ 320		$450
20	Axes	@ 10	200
20	Files	@ 2	40
	Power saw filing Equipment		50
	Parts and Maintenance		100
	Total		$840

Depreciation 100% 1 year	$ 840
Interest 12%	100
Maintenance and supplies 15%	126
	$1,066

Labor Cost

1 Power saw operator		$ 3,245
6 Laborers	@ 2,163	12,978
1 Foreman		4,326
		$ 20,549

Annual Crew Cost	21,615
Daily Crew Cost	$ 90.06
Unit Cost	.07 per cu. ft.
	2.56 per cu. m.

Forward to Roadside

Production

One cable system 1415 cu. ft./day

106 cable systems 150,000 cu. ft./day

Equipment Cost

1.4 cable system max. distance 600 meters	$ 80,000	
Spare tools, parts, etc.	30,000	
	$110,000	
Depreciation 90%; 5 years		$ 14,400
Maintenance and Repairs 15%		12,000
Interest 12% over ave. invest.		7,200
Insurance 2% over investment		1,600
Fuel and Supplies 3 gals/hr. * $1.00		6,000
		$ 41,200

Labor Cost

1 cable system operator	$ 3,245
6 Laborers @	12,978
⅓ Foreman	2,163
	$ 18,386

Annual Crew Cost $ 59,586

Daily Crew Cost $248.28

Unit Cost .18 per cu. ft.
6.19 per cu. in.

Loading

Production

1 crew @ 1,000 cu. ft. 1 day

150 crews @ 150,000 cu. ft. 1 day

Labor Cost

2 laborers @ 2,163 $4,326

Annual Crew Cost $4,326

Daily Crew Cost $ 18.03

Unit Cost 0.18 per cu. ft
.64 per cu. m.

Hauling

Production

1 Truck @ 4 loads per day	2000 cu. ft./day
75 trucks	150,000 cu. ft./day

Equipment Cost

1.4 trucks @ 60,000	$84,000	
Spare parts and tools	20,000	
	$104,000	
Depreciation 90% in 5 years		$15,120
Maintenance and repairs @15%		12,600
Interest 12% over average investment		7,500
Insurance 2%		1,680
Fuel and Supplies $0.20 per km 60,000 km per year		12,000
		$48,900

Labor

1 Truck Driver	$ 4,326
Anual Cost Per Trucks	53,226
Daily Cost $221.77	
Unit Cost	.11 per cu. ft. 3.91 per cu. m.

Crew Transportation Cost

Production	36,000,000 cu. ft /year	
Manpower:		
- Fell - Buck - Debark - Split - Pile	968	
- Forward to Roadside	795	
	1,763	
59 Thirty - passenger buses		
Equipment Cost		
1.4 * 59 buses @ $25,000	$2,065,000	
Spare and Parts	309,504	
	$2,374,504	
Depreciation (90% in 5 years)		$ 371,700
Maintenance and repairs		309,750
Interest		170,950
Insurance		41,300
Fuel and Supplies ($0.20 per km; 60 km per day * 240 days * 61)		175,680
		$1,069,380
Labor Cost		
59 Bus Drivers @ 3,245		191,455
Annual Cost		1,260,835
Unit Cost	$0.035 per cu. ft. 0.124 per cu. m.	

APPENDIX 5

COST ANALYSIS: LOWLAND TIMBER HARVESTING SYSTEM

APPENDIX 5 - COST ANALYSIS: LOWLAND TIMBER HARVESTING SYSTEM

COST SUMMARY

ITEM	$ per cu. ft.	$ per cu. m.
Variable Costs		
Fell, buck, debark, split, pile	0.07	2.56
Forward to landing	0.24	8.62
Loading	0.019	0.68
Hauling	0.032	1.12
Unloading	0.022	0.77
Crew transportation	0.018	0.65
Total Variable Cost	0.401	14.40
Fixed Costs		
Overhead	0.01	0.30
Infrastructure	0.016	0.56
Total Fixed Cost	0.026	0.86
Grand Total	0.427	15.26

Forward to Landing

Production

1	Cable System	1,415 cu. ft. per day
106	Cable Systems	150,000 cu. ft. per day

Equipment Cost

1.4	Cable Systems (600-1200m)	$ 80,000	
	Spare tools, parts	30,000	
	Steel barge 3m x 7m	20,000	
	Total	$ 130,000	
	Depreciation 90%, 5 years		$ 23,400
	Maintenance and Repairs	15%	17,200
	Interest	12%	15,600
	Insurance	2%	2,600
	Fuel and Supplies, 3 gals/hr. at $1.00		5,760
	Total		$ 64,560

Labor Cost

1	Cable System Operator	$ 3,245
6	Laborers at 2,163	12,978
1/2	Foreman at 4,326	2,163
	Total	$ 18,386

Annual Crew Cost $ 82,928

Daily Crew Cost $ 345.53

Unit Cost $0.24 per cu. ft.

$8.62 per cu. m.

Loading

Production

1	Loader	8,475 cu. ft. per day
18	Loaders	150,000 cu. ft. per day

Equipment Cost

1.4	Loader	at 40,750	$ 57,050	
	Spare Parts and tools		10,000	
			$ 67,050	
	Depreciation	90%, 5 years		$ 10,270
	Maintenance and Repairs	15%		8,560
	Interest	12%		8,050
	Insurance	2%		1,140
	Fuel and Supplies	3 gals/hr. at $1.00		5,760
				$ 33,780

Labor Cost

1 Operator	$ 3,245
1 Helper	2,163
	$ 5,408

Annual Crew Cost	$ 39,188
Daily Crew Cost	$ 163.28
Unit Cost	$0.019 per cu. ft. 0.68 per cu. m.

Hauling

Production

1	Barge	8,475 cu. ft. per day
18	Barges	150,000 cu. ft. per day

Equipment Cost

1.1	Barges	$ 110,000
.5	Tug Boat	30,000
	Spare Parts and tools	10,000
		$ 150,000

Depreciation	90%, 10 years	$ 13,500
Maintenance and repairs	10%	15,000
Interest	12%	10,800
Insurance	2%	3,000
Fuel and Supplies	7 gals/hr. at $100	13,400
		$ 55,700

Labor Cost

1/2	Tug Boat Captain at $8,000	$ 4,000
1/2	Tug Boat Engineer at $5,408	2,704
1	Barge man at $2,163	2,163
		$ 8,867

Annual Barge Cost $ 64,567

Daily Barge Cost $ 269.03

Unit Cost $ 0.03 per cu. ft.
$ 1.12 per cu. m.

Unloading

Production	36,000,000 cu. ft per year	
Equipment Cost		
Log pond and docking facilities	$ 1,000,000	
Loader (same used for loading)	----	
	$ 1,000,000	
Depreciation 100%, 10 years		$ 100,000
Maintenance and repairs (loader & facility)		434,000
Interest		66,000
Insurance		20,000
Fuel and Supplies (loaders& facility equipment)		153,680
		$ 773,680
Labor Cost		
5 Laborers @ 2,163		$ 10,815
1 Foreman		4,326
		$ 15,141
Annual Cost		$ 788,821
Unit Cost	$0.022 per cu. ft. $0.77 per cu. m.	

Crew Transportation Cost

Production			36,000,000 cu. ft. per year
	Manpower		
	. Fell - to - Pile	795	
	. Forward to Landing	795	
		1,590	People
	53 Thirty Passenger "busses"		

Equipment Cost			
	32 x 1.4 "buses" at	$ 10,000	$742,000
	Spare and Parts		74,200
			$816,200

	Depreciation	90%, 5 years	$ 146,900
	Maintenance and Repairs	15%	122,400
	Interest	12%	58,750
	Insurance	2%	16,320
	Fuel and Supplies ($0.20 per km; 60 km. per day x 240 days x 32)		152,600
			$ 496,970
Labor Costs			
	53 Drivers at $ 3,245		$ 171,985
Annual Cost			$ 668,955
Unit Cost	$0.018 per cu. ft. $0.65 per cu. m.		

APPENDIX 6

ROADS COST ESTIMATE

APPENDIX 6 - ROAD COST ESTIMATE

COST SUMMARY

ITEM	$ Per Cu. Ft.	$ Per Cu. M.
Permanent Roads		
Access roads and Primary roads		
Fixed Cost	.06	2.27
Variable Cost	.02	0.65
Temporary Roads		
Secondary roads and Spur	.04	1.33
Total	.12	4.25

PERMANENT ROAD SYSTEM

Fixed Costs

Production		36,000,000 cu. ft. per year
275 Km of access road	$ 4,950,000	
825 Km of primary road	9,900,000	
	$14,850,000	
Depreciation 15 years		$ 1,336,500
Interest 12%		980,000
Annual Cost		$ 2,316,600
Unit Cost	$.064 per cu. ft. $2.27 per cu. m.	

Variable Costs

Production		36,000,000 cu. ft. per year
Maintenance and repairs (50% of depreciation)		$ 668,250
Annual Cost		$ 668,250
Unit Cost	$0.018 per cu. ft. $..65 per cu. m.	

TEMPORARY ROADS

Production		5,300 cu. ft.
5 m. of secondary road per ha @ $8,000 per km	$ 40.00	
18.5 m of spur per ha @ $4,000 per km	74.00	
	$ 114.00	

Depreciation	$ 114.00
Maintenance and repairs	72.00
Interest	14.00
	$ 200.00

Unit Cost $.038 per cu. ft.
$1.33 per cu. m.

TOTAL DIRECT COST OF FOREST ROADS

An analysis of road cost in the Philippines, West Africa, Colombia and Brazil indicates that the following average costs may be used:

TOTAL COST PER Km	ACCESS ROADS US $	PRIMARY ROADS US $	SECONDARY ROADS US $	SPURR ROADS US $	SKIDDING ROADS US $
Easy terrain	9,000	6,300	4,000	2.000	500
Average terrain	15,000	10,200	7,300	3,700	1,200
Value Used	18,000	12,000	8,000	4,000	1,400
Difficult terrain	22,000	16,800	11,400	6,000	1,800

COMPOSITION OF ROAD COST

EXPRESSED AS PERCENT OF TOTAL COST

WORK ELEMENT	ACCESS ROAD	PRIMARY ROAD	SECONDARY ROAD	SKIDDING ROAD
Staking	1.0%	1.6%	1.4%	1.0%
Felling and formation	62.2	55.0	56.0	99.0
Clearing	3.9	5.8	8.1	--
Grading Surfacing	5.1	7.5	6.5	--
Gravelling	20.1	22.3	20.7	--
Miscellaneous	7.7	7.8	7.3	--

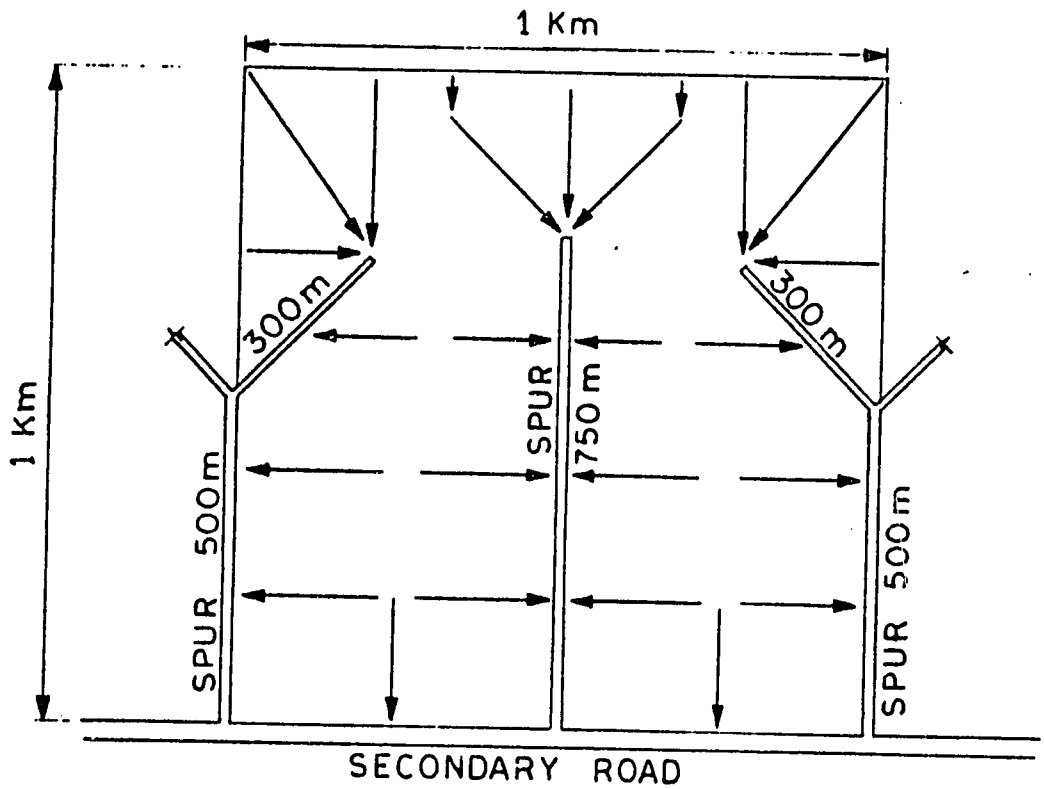


Figure 1. Road and Skidding System Layout
(For estimating purposes only)

Represents skidding distance
(Average = 200 m. (656 feet)
1 sq. km. = 100 hectares

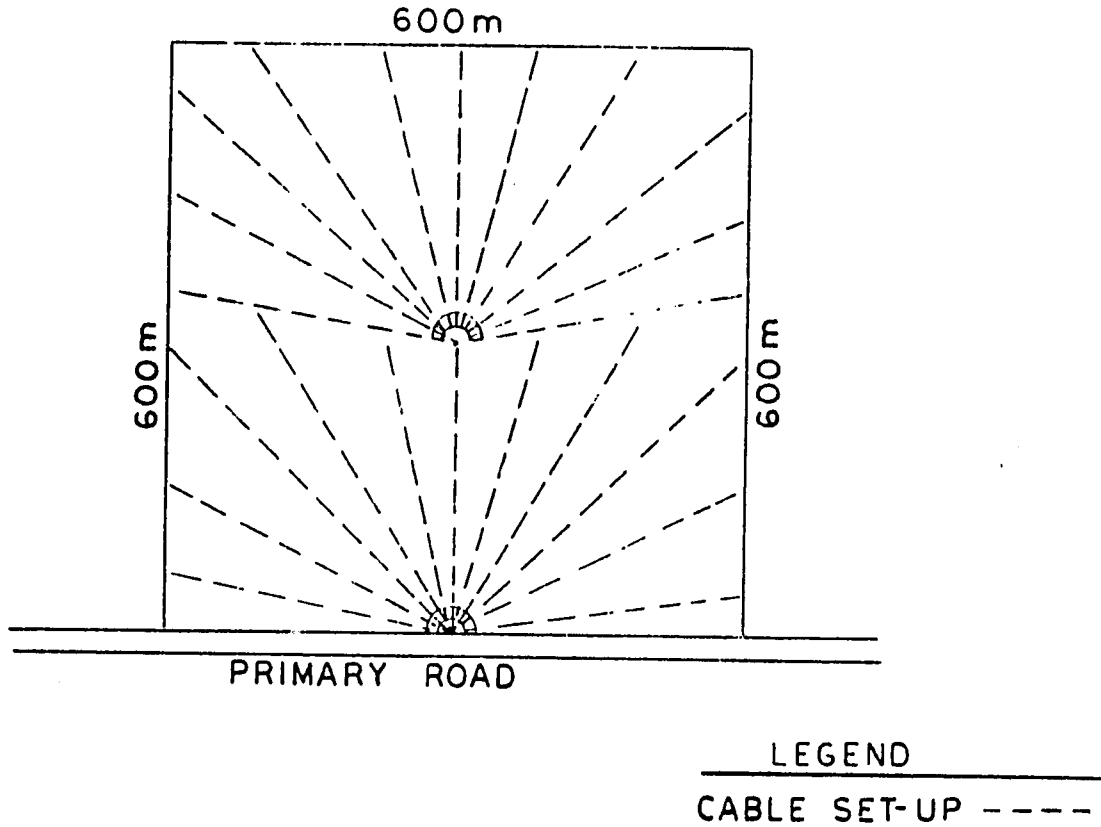


Figure 2. Road and Cable System Layout
(For estimating purposes only)

Total area 36 ha
At 150 cu. m/ha = 5,400 cu. m. timber
(190,700 cu. ft. timber)

APPENDIX 7

TIMBER HARVESTING AND TRANSPORTATION CAPITAL AND OPERATING COST ESTIMATE

APPENDIX 7

TABLE 7 - TIMBER HARVESTING AND TRANSPORTATION CAPITAL COSTS - DEPRECIATION - INTEREST - INSURANCE

TIMBER HARVESTING SYSTEM	TOTAL VALUE US $	ANNUAL FIXED COST DEPRECIATION US $	INTEREST US $	INSURANCE US $
Highland Mechanized				
Felling	43,200	43,200	5,160	---
Skidding	16,320,000	2,419,200	1,175,040	268,800
Loading	3,408,340	519,900	245,400	57,850
Hauling	7,182,000	1,052,600	516,800	117,800
Crew Transportation	482,500	75,600	30,250	8,400
Roads	14,850,000	1,336,500	980,000	---
Other Infrastructure	1,009,000	134,500	70,220	4,500
Total	43,295,040	5,581,500	3,022,870	457,350
Highland Labor Intensive				
Felling to Piling	101,640	101,640	12,100	---
Forwarding	11,660,000	1,526,400	763,200	169,600
Hauling	7,800,000	1,134,000	562,500	126,000
Crew Transportation	2,374,500	371,700	170,950	41,300
Roads	14,850,000	1,336,500	980,000	---
Other Infrastructure	1,009,000	134,500	70,220	4,500
Total	37,795,140	4,604,740	2,558,970	341,400
Lowland Harvesting System				
Felling to Piling	101,640	101,640	12,100	---
Forwarding	13,780,000	2,480,400	1,653,600	275,600
Loading	1,206,900	184,860	144,900	20,520
Hauling	2,700,000	243,000	194,400	54,000
Crew Transportation	816,200	146,900	58,750	16,320
Unloading	1,000,000	100,000	66,000	20,000
Other Infrastructure	1,009,000	134,500	70,220	4,500
Total	20,613,740	3,391,300	2,199,970	390,940

TABLE 8 - TIMBER HARVESTING AND TRANSPORTATION ANNUAL OPERATING COST

TIMBER HARVESTING SYSTEM	ANNUAL VARIABLE COST: MAINTENANCE SUPPLIES AND OTHER US $	ANNUAL VARIABLE COST: MANPOWER COSTS US $
Highland Mechanized		
Felling	6,480	367,740
Skidding	2,745,600	519,120
Loading	524,250	84,360
Hauling	1,333,800	164,390
Crew Transportation	97,560	38,940
Roads	2,026,740	---
Other Infrastructure	245,250	---
Overhead	---	311,730
Total	6,979,680	1,486,280
Highland Labor Intensive		
Felling to Piling	15,250	2,486,430
Forwarding	1,908,000	1,948,920
Loading	---	648,900
Hauling	1,845,000	324,450
Crew Transportation	485,430	191,450
Roads	668,250	---
Other Infrastructure	245,250	---
Overhead	---	311,730
Total	5,167,180	5,911,880
Lowland Harvesting System		
Felling to Piling	15,250	2,486,430
Forwarding	2,433,760	1,948,920
Loading	257,760	97,344
Hauling	511,200	159,606
Crew Transportation	275,000	171,985
Unloading	587,680	15,140
Other Infrastructure	245,250	---
Overhead	---	311,730
Total	4,325,900	5,191,155

APPENDIX 8

CHIPPING PLANT CAPITAL COST ESTIMATE

APPENDIX 8

CHIPPING PLANT CAPITAL COST ESTIMATE

FIXED COSTS - Depreciation - Interest - Insurance

Production 36,000,000 Cu. Ft.

	Item	Value US $	Period	Depreciation
1000	Site Preparation	200,000	20	$ 10,000
2000	Foundations	400,000	20	20,000
3000	Buildings	200,000	20	10,000
4000	Utilities	1,180,000	10	118,000
5000	Machinery	5,664,000	10	566,400
6000	Equipment	250,000	4	62,500
7000	Design & Engineering	350,000	20	17,500
8000	Contingency	356,000	10	35,600
	Total	8,600,000		$ 840,000

Average depreciation period 11.24 years

Average annual investment $= \frac{M + 1}{2 M} *$ Total investment

$= .544 * \$ 8,600,000$

$= \$ 4,682,562$

Annual interest - 12% $ 562,000

Annual insurance - 2% $ 172,000

Annual fixed costs - $ 1,574,000

Unit fixed cost - $ 0.04 per cu. ft.

1.54 per cu. m.

INFRASTRUCTURE

Housing (H) @ $ 75,000	$ 300,000
Other Infrastructure estimated at	1,000,000
Total	$1,300,000

Depreciation	100% in 20 years	$ 65,000
Interest	12%	81,900
Insurance	2%	26,000
Maintenance and Repairs	10%	130,000
		$ 302,900

Unit Cost $0.008 per cu. ft.
$0.30 per cu. m.

DEBARKER AND CHIPPING PLANT

Equipment Description

1. Small log deck about 36 feet long for logs up to 26" diameter. The deck to have 5 chains and stop and loaders.

2. Large log deck about 36 feet long for logs above 26" diameter. The deck to have 5 chains and stop and loaders.

3. 35" debarker complete assembly with one spare tool assembly. Barker tool to be hydraulic pressure controlled on six barker tools. The spare tool assembly on a track to allow tool repair on one set while the other set is being used. Ring w/100 HP and feed w/ 60 HP drives.

4. 50" debarker complete assembly to debark all logs about 26" diameter. Barker to have 4 hydraulic pressure control tools. Ring to have 75 PH vari-speed drive with 40 HP vari-speed feed system.

5. Over size log break down for log above the 34" spout opening on the chipper. The system to include the log deck with stop and loader, three block carriage with electric set works and log dogs only.

6. Dual arbor circle saws to quarter logs up to 50" diameter to a cross section size to fit the 34" opening on the chippers. The rollcase conveyor outfeed from the barker to be reversing and with kickers to provide a return system for quartering the logs.

7. (2) 34" V drum chippers with five knives each. Drums to rotate at 300 RPM to produce 3/4" long chips. Each chipper to have a 1,500 HP drive motor and 7 1/2 HP hold down feed roll. Feed rate of the chipper to be 112 F.P.M.

8. Surge storage conveyors from under each chipper to be multiple chains with a surge capacity to control chip flow into the 48" belt conveyor to the screen room.

9. Roto disc screen and hammermill to reduce the bark to a usable size for hog fuel.

10. Bark conveyor to be a 24" belt to convey the bark and the fine from the chip screens to the fuel pile.

11. Saw filing and grinding equipment consists of a circle saw sharpener with auxillary saw benching equipment to maintain the dual arbor breakdown saws, and a knife grinder with miscellaneous equipment for chipper knife maintenance.

APPENDIX 9

CHIPPING PLANT OPERATING COST ESTIMATE

APPENDIX 9

CHIPPING PLANT OPERATING COST ESTIMATE

Summary

	U. S. $	
	per cu. ft.	per cu. m.
Variable Costs		
Labor	.004	.14
Overhead	.005	.17
Power cost	.02	.63
Maintenance & supplies	.03	1.18
Total	.059	2.12
Fixed Costs 1/		
Depreciation-Interest-Insurance	0.04	1.54
Other Infrastructure	0.005	.17
Total	0.045	1.71
Total Cost	0.104	3.83

1/ See Appendix 7

VARIABLE COSTS

Labor

Position	Hourly Rate US $	Manpower 1st shift	Required 2nd shift	Cost Per Day US $
Scale operator	2.60	1	1	41.60
Utility clean up	1.04	1	--	8.32
Log Stacker operator	2.08	2	2	66.56
Grapple operator	2.08	2	2	66.56
Saw deck operator	1.56	2	2	49.92
Debarker - chipper operator	1.56	2	2	49.92
Screener - Air separator operator	1.56	2	2	49.92
Chip storage operator	2.60	2	1	62.40
Electrician	3.38	1	1	54.08
Millwright	3.38	1	1	54.08
Machinist-Welder	2.60	1	--	20.80
Knife grinder & Saw Filer	2.60	1	1	41.60
Mechanic	3.38	1	--	27.04
Total		19	15	592.80

Unit cost $ .004 per cu. ft.

$ .14 per cu. m.

Overhead

Resident Manager (50% to Harvest operation)	$ 30,000
Chip Plant Manager	52,500
Production Superintendent	21,000
Shift Foreman (2) @$12,000 per year	24,000
Secretary (2) @$ 6,000 per year	12,000
Clerical (3) @$ 6,000 per year	18,000
Accountant	21,000
Total Annual	$178,500

Unit Cost $ .005 per cu. ft.
$ .17 per cu. m.

POWER COST

4476 KW @ 60% demand factor = 2,685 KW/HR

@ $.0625/KW = $ 167.85 per hour

= $ 2,685.60 per day @ 150,000 cu. ft. per day

Unit cost $.018 per cu. ft.

.63 per cu. m.

MAINTENANCE AND SUPPLIES

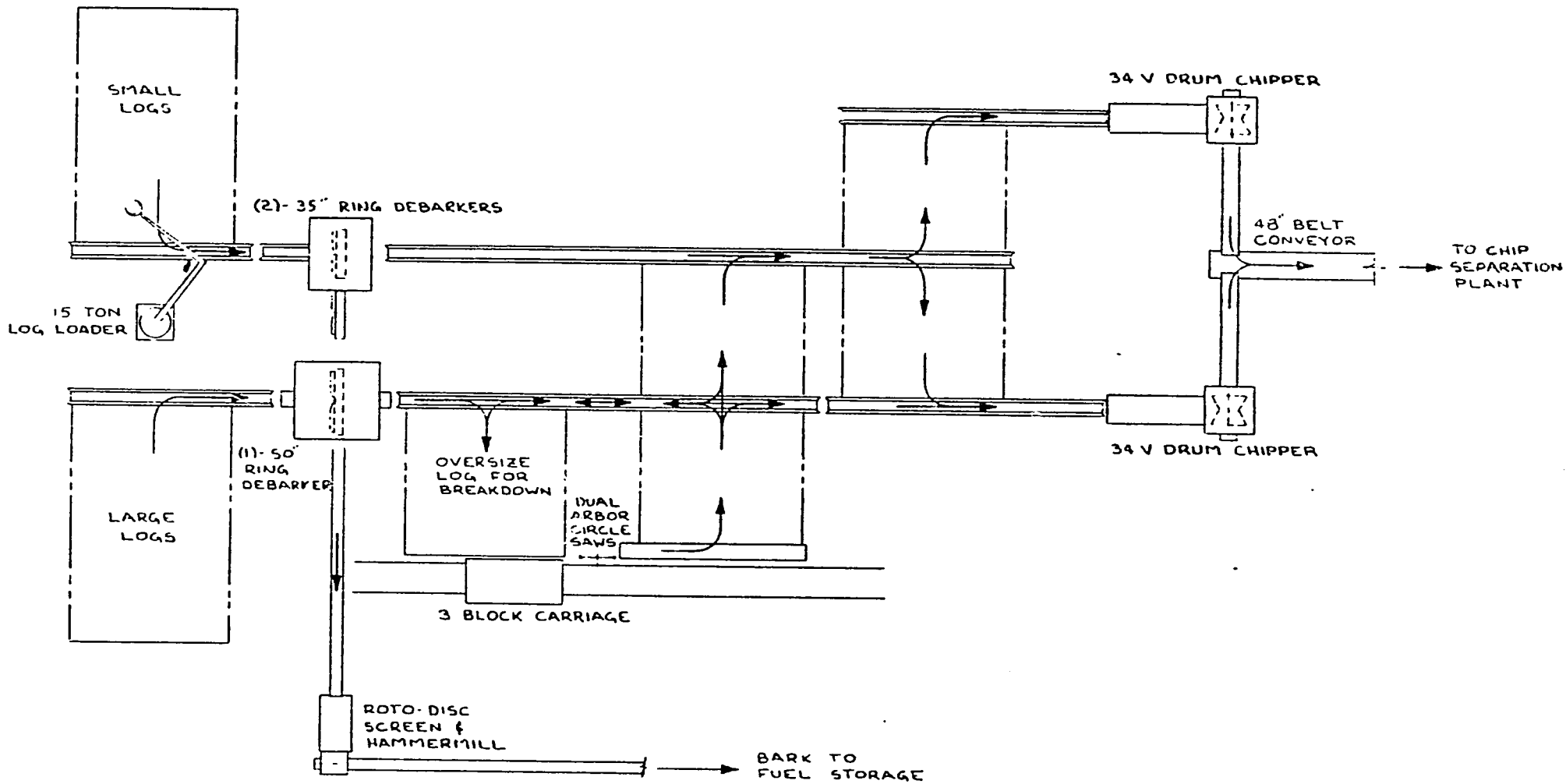
@ 15% of investment $ 1,200,000 per year

Unit cost $0.033 per cu. ft.

$1.18 per cu. m.

APPENDIX 10

DRAWING: CHIPPING PLANT PLAN



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	BY	DATE
DRAWN	HJH	11-17-77
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APP		
SCALE: 1/16" = 1'0"		

DEBARKER & CHIP PLANT
SOUTHEAST ASIA
PLAN

CHAS. T. MAIN INC.
BOSTON MASS.

CLIENTS REF. NO.	HCMA DRAWING NO.	REV
	1191-12-05000-001	

INFRASTRUCTURE REQUIREMENTS

GENERAL

The specification from the Forest Products Laboratory requests that a checklist be developed for infrastructures necessary and desirable for efficient operation of the forest products facility. The infrastructure definition used is to include items not normally required for pulp mills in a developed country, and to include unusual requirements in services and materials.

The mill location is in Southeast Asia in an area remote from a developed population center. The site is assumed to be on the seacoast so that materials are available by ocean shipping and that pulp can be transported directly from the mill warehouse by ship also. The topography is assumed to be relatively flat with no unusual earth movement required for site preparation and no unusual foundation requirements.

Costs of permanent roads for woods operations are shown separately from other infrastructure costs.

As is well known, infrastructure costs vary widely depending on location. The costs shown in this report are general in nature based on hypothetical conditions. Further studies would be required for a particular site location to accurately define true infrastructure costs.

The checklist of items in infrastructure include:

1. Shipping Facilities - Shipping facilities consist of warehousing and a pier suitable for shipping pulp by ocean going vessels. This pier will also be used to receive chemicals, fuel oil and other raw materials used in manufacturing.

2. Land Transportation - Since the mill site is located on ocean frontage, land transportation requirements are minimized. A system of permanent and temporary roads for woods operations will be required, along with vehicles associated with wood handling.

   In addition to a normal mill road system, a road from the mill to the pier will be required. Normal mill vehicles and trucks for pulp movement are included in mill costs.

   A road network through the mill community is required also.

3. Chemicals - For the purposes of this preliminary report we are assuming that chemicals will be purchased. We realize that in the present situation it is common for a chemical plant to be included with a pulp mill. In this particular case we have elected to purchase chemicals and the cost of these are reflected in the operating cost of the pulp mill. If the alternate were chosen the capital cost of the pulp mill would increase and operating costs would decrease somewhat. We suggest that if a further study is made with more detailed investigation, that an economic analysis must be made of manufacturing versus purchasing chemicals.

4. Water Supply - It is assumed that water will be obtained from a river approximately 10 miles from the mill site and that a pipe line will be constructed from that source to the mill. Normal water treatment facilities will be installed at the mill.

5. Fire Protection - Several fire trucks and other fire fighting equipment will be housed in a garage within the compound for fire protection. It is anticipated that the fire department would be served by a designated group within the mill.

6. Power & Light - From generating facilities within the mill a distribution system will be installed to supply power and light to all housing and amenities within the compound. In addition it is anticipated that a lighting system will be supplied to the community and that limited power will be made available to establishing businesses in the community.

7. Communications - A telephone system will be installed for communications within the mill. In addition, a telephone tie will be made to outside telephone service, through a microwave system installed in coordination with local communications companies. In addition, a radio telephone system would be installed as another means of communication outside the mill.

8. Housing - Housing will be provided within the compound for expatriate personnel and senior staff. In addition a guest house and several guest cottages will be provided for housing visiting personnel from within the company, for vendors or other visiting dignitaries. The guest house will include facilities for dining and recreational amenities.

9. Security - The entire mill compound of manufacturing facilities, staff housing and amenities will be surrounded by a fence. Entrances to the compound will be guarded on a 24 hour basis. Associated security devices will be installed to augment the security force.

10. Schools - It is planned to establish a school system for children of senior staff personnel within the compound. It is anticipated that limited support will be given also to a school system for the community outside the compound.

11. Medical Facilities - A hospital will be required for the mill with adequate equipment and staff to take care of the needs of personnel within the compound. It is assumed that the medical facilities would be available also to residents of the mill community.

12. Religious - A non-denominational house of worship will be provided for staff personnel with availability for community residents. It is anticipated that the ministers of the various faiths will be drawn from local religious groups.

13. Community - It is anticipated that a small community will develop outside of the mill compound. There will be assistance provided to the community to allow it to become established but it is not anticipated in the present cost to provide housing for the community. It is anticipated that local merchants will become established and that a business community sufficient to serve the local needs will become developed.

As mentioned previously, infrastructure requirements vary considerably depending on location. In some countries, certain infrastructure costs may be borne by the government, thus lowering capital costs as shown in this study.

It should also be noted that by definition, this study involves a pulp mill and fibreboard facility development in a new area, without earlier less capital intensive steps. To spread infrastructure costs, it may be desirable to start a new development as a logging operation, followed by a lumber operation, fiberboard and then a pulp mill.

U.S. DEPARTMENT OF AGRICULTURE
FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

SECTION 1

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

GENERAL

The manufacture of high quality bleached kraft pulp from mixed tropical hardwood is now an established fact both from tests at US Forest Products Laboratory and from commercial operations.

The high cost and uncertain availability of fuel oil has caused many mills to experiment with substitution of high percentages of wood waste for oil in power boilers.

These two features have been combined in a 500 T/D bleached kraft pulp mill for this study.

The major design modifications required for a mixed tropical hardwood pulp mill as compared with a temperate zone hardwood pulp mill are as follows:

A. Increased wood handling and processing facilities are provided to account for the somewhat lower yield from mixed tropical hardwood (due to higher non-cellulosic organics contant); and the wood supplies as fuel to the wood fuel boiler.

B. The digester capacity has been increased due to lesser unbleached pulp yield.

C. A brown stock pulp centrifugal cleaning system is included to aid in removal of pitch, characteristic of many tropical hardwoods.

D. The liquor evaporation system and recovery furnace are sized to match liquor flows.

E. A larger power boiler is requried to compensate for the lower combustion efficiency when wood is substituted for most of the oil as fuel. Wood burning will require a larger grate surface and increased ash handling equipment.

FOREST PRODUCTS LABORATORY PRELIMINARY INDUSTRIAL SURVEY MIXED TROPICAL HARDWOOD 500 T/D KRAFT PULP MILL	SHEET 1 OF 1 JOB NO. 3254-1 DATE: Dec 20, 1977
DATA FOR BASIS OF DESIGN GENERAL	MAIN

<u>Kraft Pulp Production - From Dryer</u>	
Nominal Design Rate - ADT/Year	175,000
Operating Days Per Year	350
Peak Design Rate - ADT/Day	570
Mill Efficiency Factor - % of Peak Rate	.88
Nominal Design Rate - ADT/Day	500
Nominal Design Rate - ODT/Day	450
<u>Yield - % Bleached</u>	40
<u>Bleached Pulp Yield Per Cubic Meter Solid Wood</u>	
Total OD Lbs. Per OD M^3	373
<u>Heating Value of Fuels</u>	
Fuel Oil - BTU/Lb	18,000
Black Liquor Dry Solids - BTU/Lb	6,300
OD Wood - BTU/Lb	8,500

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN

PERSONNEL REQUIREMENTS

MAIN

	SHIFT		DAY			
Department	Workers	Supervisors	Workers	Supervisors	Office	Managers
Pulping	10	5	3	2		
Evaporation & Recovery	15		5	1		
Liquor Preparation	10		2	1		
Bleach Plant	10		3	1		
Bleach Chem. Prep.	15		3	1		
Pulp Process & Finishing	45	5	5	2		
Warehouse			12	1		
Water Treatment & Effluent	20		2	2		
Wood Fuel Boiler	15	5	5	1		
Technical				1	30	
Maintenance & Trans.	30	10	120	2		
Office, Clerical, Security	25		95	5	135	25
Production Management				10		10
Sub Totals	195	25	255	30	165	35
TOTAL						705

SECTION 2

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

PERSONNEL AND ECOLOGICAL PROTECTION

Ecological and personnel protection requirements of the mill site and adjacent area have been considered. All process and personnel facilities have been designed to meet the requirements of the United States Occupational Safety and Health Act safety codes and Federal requirements stipulated in various applicable laws.

A. Safety and personnel hazard prevention
B. Air emission abatement
C. Effluent containment and/or treatment
D. Site erosion and appearance protection

A. Safety and Personnel Hazard Prevention

Normal design practices to protect operating personnel have been enhanced to meet the most recent requirements of OSHA codes and other health and safety protective requirements. Typical facilities are as follows:

1. Dual building exits
2. Access, walkway design
3. Insulation to prevent exceeding specified contact temperatures.
4. Moving equipment guards
5. Relative location of control room vs boilers
6. Noise enclosures in areas of high noise level
7. Construction safety protection

B. Air Emission Abatement

1. Unbleached Pulp Mill - Selected vent gases from the chip bin, digester, tanks and hoods will be collected, and incinerated in the Lime Kiln or Recovery Boiler depending on concentration and volume.

2. Bleach Plant - Selected vent gases from bleaching towers and washer hoods will be collected and scrubbed for containment and absorption.

3. Black Liquor Evaporators - Exhaust contaminated vapors will be condensed in a tubular surface condenser system followed by incineration of non-condensible gases. Vents from condensate and liquor storage tanks will be collected, cooled and incinerated.

4. Recovery Boiler - Dissolving tank and saltcake mix tank vents will be collected and disposed of in the recovery boiler. Exhaust flue gases from the boiler will be treated by a high efficiency electrostatic preciptator.

5. Causticizing - The vent gases from the slaker will be scrubbed, those from the white liquor tank will be incinerated. Vent gas from the lime kiln will be scrubbed in a high energy (and efficiency) venturi unit.

6. Utilities - Wood Fuel Boiler - Vent flue gas from the boiler will be subjected to two stage fly ash collection. Nitrous oxides emission protection will be provided for in the size and design of the boiler.

C. Effluent Containment and/or Treatment

1. Woodyard and Woodroom - Dry barking capacity will be provided.

2. Unbleached Pulp Mill - Pressure screening will be provided to eliminate traditional screened stock thickener filtrate effluent, containing BOD and color. Contaminated digester vent condensate will be collected and steam stripped. Facilities will be provided to capture, store and reprocess major black liquor spills through the evaporators and unbleached fiber spills over the screened pulp rewasher. Screenings and cleaner rejects will be disposed of by incineration.

3. Bleach Plant - Piping will be provided for complete countercurrent re-use of washer filtrates. Facilities will be provided to capture, store and reprocess major fiber spills over the screened pulp rewasher.

4. Pulp Finishing - Waste heat from the dryer will be contained and used for water heating, rather than imposing a heat load on effluent. Excess white water at elevated temperature will be re-used in the bleach plant.

5. Black Liquor Evaporator and Recovery Boiler - Contaminated condensates from the digester and evaporator areas will be collected and steam stripped. Non-condensible gases will be incinerated. Stripped condensates will be re-used in process. A surface condenser will be provided for the exhaust vapors from the evaporator to eliminate contamination of cooling water. Minimum cooling water will be required for and contaminated by the vacuum ejector system. Major black liquor spills will be captured, stored and reprocessed through the evaporators.

6. Liquor Preparation - A liquor spill system will be provided to eliminate the accidental dumping of liquor to the effluent system. This will consist of a collection sump, sump pumps and a dump/spill tank. From the storage tank, it will then be pumped back to process.

   A Mud Spill System will be provided to eliminate the accidental dumping of lime mud to the effluent system. This will consist of a collection sump and a lime mud holding lagoon. From the lagoon, mud will be returned to process.

7. Utilities - Turbine-Generator - The cooling water from the condenser will be re-used in process to the best extent possible.

8. Utilities - Wood Fuel Boiler - Ash will be transported in semi-dry form to eliminate a possible source of effluent from ash sluicing. Sludge from the effluent treatment plant will be dewatered and incinerated in the Wood Fuel Boiler.

9. Utilities - Auxiliaries - A neutralizing system will be provided for demineralizer waste chemicals.

10. Water Treatment Plant - Backwash water from the filters and underflow from the primary clarifier will be transferred to the effluent treatment for disposal.

11. Effluent Treatment - Primary and secondary effluent treatment of segregated mill effluent will be provided. Clarifier sludge will be transferred to the wood fuel boiler area for incineration.

12. Personnel Sanitary Effluent - Complete collection and a package treatment system will be included.

D. Site Erosion and Appearance Protection

Seeding and planting for erosion protection and appearance will be included.

SECTION 3

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

PULPING

The pulping operation will be based on a continuous cooking system because this is a single product mill, and in order to reduce energy requirements. The digester will be hydraulic type with capacity required to produce design tonnage at 40% bleached yield for mixed tropical hardwoods, and allowing for two hours of retention time for the purpose of high heat washing the pulp and recovering the cooking liquor.

The digester will be followed by a two stage diffusion washing system for additional pulp washing and recovery of cooking liquor.

This washing operation will be followed by pressure knotters, screens and cleaners. The separated knots will be returned to the digester for recooking, and final rejects from screening and cleaning will be pressed and burned. The knotting and screening system will be designed to operate under pressure. A three stage cleaning system will remove dirt and pitch from the pulp after screening. The screened and cleaned pulp rewasher will operate not only as thickener but also as a final pulp and liquor recovery washer. The recovered liquor filtrate will be cascaded back through the screening system to the second stage diffuser into the washing zone of the digester and then to evaporation.

Pulp screening will be done in three stages of rotary screens and two stages of centrifugal cleaners. Acceptance will be from the first stage screens only. Accepted pulp from each following stage is returned to the preceding stage. Rejects from the screening system cleaners will be pressed and burned in the wood fuel boiler.

The screened pulp will be diluted and cleaned in a three stage centrifugal cleaning system. Accepts from the first stage cleaner will be washed and thickened on the brown stock rewasher. A high percentage of the pitch will be rejected by the cleaners.

The screened, cleaned and washed pulp will be stored in tanks at high consistency.

Offensive odors or gas will be captured from hoods, vents, and exhausts and directed to an air emission control system.

The pulp rewasher will also function to thicken bleached or unbleached pulp spills to permit re-entry into the production line.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

PULPING

DIGESTER AREA

Continuous Digester
Chip Meter
Low Pressure Feeder
HP Feeder
Steaming Vessel

LIQUOR RECOVERY

1st Stage	120 min. of Diffusion Washing in Digester
2nd Stage	Ring Diffuser Washer
3rd Stage	Ring Diffuser Washer
4th Stage	Vacuum Rewasher/Thickener
4th Stage Seal Tank	

DEKNOTTING

Pressure Knotters
Vibratory Knot Drainers

SCREENING

Primary Screens	Pressure Centrifugal
Secondary Screens	Pressure Centrifugal
Tertiary Screen	Pressure Centrifugal
Quarternary Screen	Vibratory Screen

REJECTS CLEANERS — 2 Stage Centrifugal

CLEANING SYSTEM — 3 Stage Centrifugal

BROWN STOCK STORAGE

Diffuser Storage	10% Consistency - Steel
Washed Stock Tank	12% Consistency - Tile

SECTION 4

MIXED TROPICAL HARDWOOD

BLEACHED KRAFT PULP MILL

LIQUOR RECOVERY - EVAPORATORS

Weak black liquor from the digester flash tanks will be stored in one tank. A supplemental black liquor spill tank will be provided to collect major accidental liquor spills and serve as added storage capacity.

Weak black liquor will be pumped to the six-effect, six-body evaporator set. Internal heaters will be provided in all effects to increase thermal efficiency. The rated evaporative capacity will provide for the higher liquor flow expected from mixed tropical hardwoods, and intermittent cleaning requirements, as well as the reprocessing of liquor collected during spills.

Black liquor will be pumped from the first effect of the evaporator to an intermediate storage tank (55% solids) and then in turn pumped to the two-body concentrators. The entire set will be designed so that the set can operate 100% capacity while one of the concentrators is being boiled out. Strong black liquor storage tank will be provided.

Contaminated condensates from the evaporation system and digester system will be collected in a surge tank and then stripped with steam in a Contaminated Condensate Stripper. Condensible volatiles will be separated from the stripped vapors and mixed with black liquor for incineration in the recovery furnace. Stripped non-condensibles will be collected in the Odorous Gas Collection System for incineration in the Lime Kiln.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

EVAPORATORS

Multiple Effect Evaporator Set with Concentrators	62% solids average 35 psig steam @ Concentrator & 1st Effect 4" Hg in 6th Effect with 85°F cooling water
Weak Black Liquor Storage Tank	One
Black Liquor Spill Tank	One
Intermediate Storage Tank	One
Strong Black Liquor Storage Tank	One
Contaminated Condensate Stripper	The stripper will handle condensate from the 5th effect, 6th effect and surface condensor of the evaporator set and condensate from the continuous digester.

LIQUOR RECOVERY - RECOVERY BOILER

The black liquor recovery boiler will be modern, low odor type unit with large economizer and without flue gas direct contact evaporator.

The rated capacity of this boiler will provide ecological protection for peak operating conditions and surges generated by captured major liquor spills. The electrostatic preciptator capacity will match the recovery boiler and will be rated to remove 99.7% of the particulate matter in the flue gas from the recovery boiler at design conditions.

Recovery Boiler

This equipment will consist of a smelter furnace including smelter hearth and furnace bottom and chemical retort area at the bottom of the furnace; waterwalls, superheater, boiler and economizer; complete setting including all refractories and insulation; complete exterior aluminum and steel casing; motor driven forced draft air fans; steam coil air heaters for combustion air; turbine driven induced draft fan; black liquor fuel nozzles and drives; chemical ash hoppers; water cooled smelt spouts complete with green liquor shatter spray nozzles and steam shatter nozzles; main smelt dissolving tanks with side entering agitators; load oil burner equipment for startup and emergency service complete with oil burned monitoring system; steam sootblowing equipment. The dissolving tank vents will be connected to the flue between the economizer outlet and the electrostatic preciptator inlet. The boiler, in addition to standard combustion and liquor controls, will be equipped along with the electrostatic preciptator with additional controls and a rapid drain tank to permit operation of the emergency shutdown procedure required by the latest TAPPI Black Liquor Recovery Boiler Advisor Committee standards.

Electrostatic Preciptator

This equipment will be a double chamber dry bottom type. Flue gates will be provided at the inlet and outlet of each chamber in order that one chamber may be shut down for maintenance and repairs and all the flue gas from the recovery boiler will pass through the other chamber. Induced draft fans and flues will be sized to accomplish single chamber operation. The precipator will have a minumum of six (6) electrical fields. Transformer-rectifier sets and pneumatic rappers will be located on the roof. The precipator dry bottom will consist of a system of scraper conveyors which will deliver the collected material in a dry state to the black liquor mixing drums at either side of the precipator bottom.

Salt Cake System

A salt cake day silo will be provided in the recovery boiler building. A feed system will be provided to feed the salt cake to the sale cake mix tank. The salt cake mix tank will be designed for combined salt cake mixing and chemical ash mixing service.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

RECOVERY BOILER

Recovery Boiler

- Boiler & Superheater
- Setting & Aluminum Casing
- Economizer & Soot Blowers
- Steam Coil Air Heaters
- Salt Cake Mix Tank
- Chemical Ash Hoppers
- Dissolving Tank
- Oil Burning Equipment
- Windboxes and Ductwork

Electrostatic Preciptator	99.7% efficient
Flue Gates	Four
Primary F.D. Fan w/Motor Drive	
Secondary F.D. Fan w/Motor Drive	
I.D. Fan, turbine drive	
Smelt Spout System	
Rapid Drain Tank	
Flues & Ducts	
Main Stack	

SECTION 6

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIQUOR PREPARATION

GENERAL

The liquor preparation system will be comprised of a conventional gravity type settling equipment for the recausticizing area and a standard rotary kiln with related auxiliaries for the lime reburning process, and sized large enough to provide 15% more cooking liquor than for a standard hardwood kraft mill of this size.

RECAUSTICIZING SYSTEM

Green Liquor Clarification & Dregs System

Smelted green liquor from the recovery boiler dissolving tank will be transferred via a stainless steel trough to the Green Liquor Clarifier.

The Green Liquor Clarifier will be a single compartment, unit type clarifier, with the upper portion of the tank used for storage of clarified green liquor. ODS pumps will transfer dregs to an agitated tank. Dregs will flow by gravity to a vacuum filter. Filtrate from the dregs filter vacuum system will be pumped to the weak wash storage tank.

Slaking/Causticizing

A lime slaker of all stainless steel construction will be supplied. The slaker vent stack will have internal sprays for stripping the exhaust gases before discharge to the atmosphere.

Three causticizers will follow the slaker and will provide 1.5 hours retention time for completion of the reaction. The causticizing tanks will be lined with a 3-inch alkaline-resistant lining.

White Liquor Clarification

A single compartment, unit type with white liquor clarifier with the upper portion of tank serving as clarified white liquor storage will be provided. Clarified white liquor will flow by gravity to clarified white liquor pumps for transmission to the digesters.

Lime Mud System

White liquor clarifier underflow solids will be pumped to a lime mud mix tank for dilution from 35% solids to 10% solids. From there, the mud will be pumped to a single compartment, unit type mud washer with the upper portion of the tank serving as weak wash storage. The mud washer underflow will be pumped at 35% solids to an agitated lime mud storage tank.

Lime Mud Filter

Lime mud from the storage tank will be diluted and pumped to a pre-coat filter. Mud will be dewatered and discharged directly to the kiln feed screw conveyors.

LIME KILN SYSTEM

The lime kiln will be a long kiln.

The lime kiln auxiliaris consist of a No. 6 fuel oil burner complete with flame failure system, step variable speed kiln drive, reburned lime conveyors, and reburned lime silo. The kiln exhaust system will consist of a hot induced draft fan complete with inlet dampers, hi energy, variable throat venturi scrubber with cyclone separator and ducted to the stack. The induced draft fan has been sized for a 27-inch venturi scrubber differential to remove soda fume and lime dust in the kiln exhaust gases to meet 0.5 lb/ton particulates from the stack.

Chemical Handling Systems

Limestone for causticizing makeup will be unloaded and stored in the Liquor Preparation Area. Limestone makeup quantities will be controlled with feeders. Makeup lime to causticizing will discharge into the lime mud feeder conveyors at the feed end of the kiln.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

LIQUOR PREPARATION

GREEN LIQUOR SYSTEM

Raw Green Liquor Storage Tank
Green Liquor Clarification Clarifier
Clarified Green Liquor Storage Tank
Dregs Filter

WHITE LIQUOR SYSTEM

Unclarified White Liquor Slaker
Causticizing Tanks
Clarification
White Liquor Storage Tanks

LIME MUD SYSTEM

Lime Mud Washer
Weak Wash Storage
Lime Mud Filtering and Dewatering

LIME STONE

Lime Stone Storage Area

LIME KILN SYSTEM

Lime Kiln
Reburned Lime Storage Silo

MISC. TANKAGE

Dump Tank (& Spill Tank)

SECTION 7

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

BLEACHING

Bleaching will be accomplished in five stages -- Chlorination, Caustic, Chlorine Dioxide, Caustic, Chlorine Dioxide.

Flexible retention time has been introduced into the chlorination stage to take care of variations in temperature. This will be accomplished by two retention towers. These towers can be operated in series resulting in 30-minute retention time or individually resulting in either 20-minutes or 10-minutes. This bleaching stage will be followed by a drum washer constructed of titanium and fiberglass.

The remaining four stages will be down-flow bleaching towers followed by drum washers fabricated of type 317 stainless steel. The bleaching tower design capacity will be based on acceptable retention time for peak operation.

The washers will be completely enclosed with fiberglass hoods. Exhaust fumes from all sources will be captured and directed through a scrubber before releasing to the atmosphere.

The bleaching operation is followed by high consistency pulp storage tanks.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

BLEACHING

Bleaching Sequence	5 Stage CEDED
Chlorine Stage	
Mixer	
1st Tower (Upflow)	
2nd Tower (Upflow)	
Washer	
Caustic Extraction	2 Stages
Mixers	
Towers (Downflow)	
Washers	
Chlorine Dioxide	2 Stages
Mixers	
Mixers	
Towers (Upflow)	
(Downflow)	
Washers	
Bleached Stock Storage	12% Consistency - Tile

SECTION 8

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

BLEACH CHEMICALS

The unloading and storage of all chemicals used in the pulping operation and manufacture of chlorine dioxide will be consolidated in one area as a single operation. In order to reduce the initial capital cost of the mill, chlorine dioxide only, will be generated on site. These facilities will be isolated from the main mill to avoid contamination.

The following chemicals will be handled in this area:

1. Chlorine - Received in liquid form. This system will be complete with air compressor and air drying exclusively for use on chlorine service and vaporizing system.

2. Caustic - Received at 50% concentration. Two tanks will be provided. One tank will be used to store the unloaded caustic at full concentration. The second tank is used to store the caustic after it has been diluted for use in the process.

3. Sodium Chlorate - Received at 99% concentration. Facilities for unloading will be in a designated area, separate from all other chemicals, with provisions for wash-up to avoid a flammable condition. Two tanks will be provided, one for unloading chlorate, and the other storing the 46% solution for use in the process.

4. Sulfuric Acid - Received and stored at 93% concentration.

5. Sodium Chloride - Received in dry crystal form. A lixator for dissolving the salt crystals and storing the saturated brine solution for use in the process will be included.

6. Sulfur Dioxide - Received and stored in liquid form. An air padding system will be included.

Chlorine Dioxide - This is the principal bleaching chemical and is manufactured on-site.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

BLEACH CHEMICALS

Chlorine Air Compressor
Chlorine Vaporizers
50% Caustic Storage Tank
Dilute Caustic Storage Tank
Sodium Chlorate Unloading Tank
Sodium Chlorate Storage Tank
Sulfur Dioxide Storage Tank
Sulfur Dioxide Air Compressor
Chlorine Dioxide Storage Tank No. 1
Chlorine Dioxide Storage Tank No. 2
Salt Cake Solution Storage Tank
Salt Cake Storage Tank Agitator
Sulfuric Acid Storage Tank
Sodium Chloride Lixator

SECTION 9

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

PULP DRYER

The pulp drying facility will be essentially a conventional fourdrinier wet end - air-born dryer pulp machine installation with a cutter and layboy.

The pulp will be received from pulp mill storage chest at approximately 3-1/2% B.D. consistency, and held for a period of up to 15 minutes in a blending chest. Machine broke from the broke storage chest will also go to this blending chest. Stock from the blending chest will be diluted to approximately 0.5% B.D. consistency, cleaned in centrifugal cleaners to remove dirt and pitch, then thickened to approximately 3-1/2% B.D. on open type gravity deckers and held in a tile machine chest. The water used for dilution for the most part is continuously recirculating through the cleaning system.

The air-borne dryer will operate on 150 lb. steam. The dryer will be equipped with a sheet cooler. Appropriate air supply and exhaust systems will be employed for maximum operating efficiency.

The pulp machine will consist of a high performance type headbox, a fourdrinier with suitable drainage devices and a lump breaker roll, one felted suction press, a felted Grooved second press, four pre-dryers unfelted, and a third felted Grooved press.

The fourdrinier will have a combined wire pit and tray water silo. The fan pump suction will be from the silo with stock from the machine chest entering the system at the fan pump suction. Excess waters from the wet end will be used for consistency dilution etc. with the surplus white water being returned to the bleach plant.

The baled pulp facility will consist of a cutter, perforator, and layboy, two 1000 ton bale presses and completely automatic bale wrapping, tying and unitizing equipment. Weigh scales with roll up record will be provided for both the individual bales and stacks.

BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

PULP FINISHING

Secondary Screen
Tertiary Screen
Centrifugal Cleaners - 3 Stage
Fourdrinier Wet End
Press Section
Pre-Dryer Section
Pulp Dryer
Sheet Cooler
Cutter-Layboy
Dry Pulp Bale Make-up Scale
Dry Pulp Bale Presses
Dry Pulp Bale Stacker
Dry Pulp Stack Scale

SECTION 10

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

PULP WAREHOUSE

A fully sprinklered pulp storage warehouse, with 40,000 square feet of effective storage area, will be located along side the pulp processing and drying building. Roof height will be sufficient to store dry bales 12 bales high with sufficient clearance under steel for sprinkler requirements. Storage area will be sufficient to store 13,000 tons of baled pulp.

Truck docks to load pulp for shipment will be provided. Docks will be arranged so that six (6) trucks can be worked at the same time.

SECTION 11

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

WATER TREATMENT

RIVER PUMP HOUSE

It is assumed that water for the mill will be taken from a river.

Water will enter the pump house through trash racks and automatically cleaned traveling water screens into a pump well.

From the pump well, water will be pumped through a 30-inch pipeline to the mill site. All pumps will be of the vertical turbine type.

WATER TREATMENT PLANT

Water from the river pump house will enter the water treatment plant after passing through the turbine condenser, the ClO_2 chiller or direct from the river pump house.

Water for use as filtered water in the mill will pass through a clarifier and automatic backwash filters. Water for use as raw water in the mill will be from the river pump house with no treatment.

Chlorine will be added to the raw water ahead of the turbine condenser, ClO_2 chiller and clarifier and to the clarified water ahead of the filters.

Alum, caustic and polyelectrolyte will be added ahead of the clarifier. Caustic will be added to the filtered and raw water before delivery to mill to adjust the pH.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

WATER TREATMENT

Motor driven turbine type pumps
Motor or diesel driven turbine type pump
Traveling water screens
Clarifier
Clearwell (Steel)
Hardinage automatic backwash filters
Alum feeding system
Polyelectrolyte feeding system
Caustic feeding systems
Chlorine feeding systems

SECTION 12

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

WATER DISTRIBUTION

Filtered water will be pumped from the filtered water clearwell located under the filters throughout the mill as required.

Raw water will be pumped by motor driven pumps located in the water treatment plant. Raw water will come from the river with no pretreatment. A piping system will distribute the raw water throughout the mill where required.

Filtered and raw water will be treated with chlorine and caustic to control the slime and pH in the systems.

Flow of water in the systems will automatically control the operation of the pumps.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

WATER DISTRIBUTION

Motor driven filtered water pumps (1 spare)
Motor driven raw water pumps (1 spare)

SECTION 13

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

UTILITIES - EFFLUENT TREATMENT SYSTEM

The effluent treatment system will consist of facilities to treat process wastewater, and sanitary wastewater. Process wastewater will receive secondary treatment in a modified aerated stabilization basin system. Sanitary wastewater will be treated in a "package" extended aeration treatment plant.

All of the above wastewaters are collected in a common outfall line and flow through a foam control structure and a diffuser to the river.

Process wastewaters will leave the mill in two sewers, an acid sewer which carries the wastewaters low in suspended solids, and an alkaline sewer which carries the wastewaters with settleable solids. The pH of the acid sewer wastewater will receive primary treatment in a clarifier. The overflow from the primary clarifier will be mixed with the acid sewer wastewater prior to pumping to the aerated stabilization basin.

The contents of the two stabilization basins will be mixed and aerated for up to a four-day period using floating mechanical aerators. Effluent will flow to the outfall.

Clarifier solids will be sent to the mill for dewatering on two vacuum filters and further dewatered in a sludge press. The solids will then be incinerated in the wood fuel boiler.

The treatment system will include pumps, monitoring and control equipment, and a laboratory. Continuous sampling and analysis will be used to assure the highest possible effluent quality.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

UTILITIES - EFFLUENT TREATMENT SYSTEM

Bar Screen
Primary Clarifier
Stabilization Basin
Aerators
Secondary Clarifier
Foam Control Structure
Emergency Solids Handling Ponds
Vacuum Filters & Accessories
Screw Press
Screw Conveyors
Flotation Thickener
Effluent Lift Pump

SECTION 14

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

UTILITIES - TURBINE GENERATOR

The turbine will be an automatic, double extraction, condensing type with a standard turbine frame size of 20,000 kW. The generator will have rated capacity of 30,000 kVA at 13,800 volts.

The turbine will be furnished complete with lubricating oil system, electrohydraulic governing and control system, high pressure hydraulic system and oil purification, main turbine trip and throttle valve with integral steam strainer, extraction check valve for both extractions, set of supervisory instruments, low vacuum tripping device and relief diaphragms rotor turning gear, and gland sealing and gland leakage evacuating system.

The generator will be hydrogen cooled standard generator directly connected to the turbine.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

TURBINE - GENERATOR

Turbine
Generator
Surface Condenser & Auxiliaries
Oil Purification System

SECTION 15

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

UTILITIES - WOOD FUEL BOILER

The boiler will be designed to use wood and wood waste as its principal fuel. Approximately 20% of the steam from the wood fuel boiler will result from the combustion of fuel oil. The fuel oil is required to respond to rapid swings in mill steam and power demand.

This boiler using mixed fuels as described will be approximately 20% larger than one designed for oil due to lower combustion efficiency.

The boiler will consist of continuous ash discharge traveling grate, main furnace, waterwalls, boiler superheater, economizer, setting including all refractories and insulation, complete exterior steel and aluminum casing, tubular air preheater, main oil burning equipment, fly ash reinjection system, sand classifiers, stoker distributor air supply system, flues, ducts and windbox, fly ash hoppers, furnace bottom enclosure, soot blowers, with future provisions for coal burning.

The forced draft fan will be motor driven. Induced draft fan will be equipped with turbine drive.

Nitrous oxide emission control is provided in the design of size and capacity of this boiler.

Two-stage mechanical fly ash collectors will be furnished to meet air emission control standards. Outlet flue from fly ash collectors will be connected to the stack.

Wood chips along with bark from the woodroom will be conveyed pneumatically to the cyclone separator at the wood fuel boiler. From the separator the wood fuel will flow by gravity through a chip distributor, chip feeding bin, and chip chutes to the stoker distributors on the wood fuel boiler. A wood chip feeding bin by pass will be provided.

Underflow sludge from the primary and secondary clarifiers of the effluent treatment plant will be pumped to the boiler area. There it will be mixed with screen room tailings and then dewatered on drum filters and pressed suitable for incineration in the wood fuel boiler.

Fly ash from the continuous ash discharge grate and the mechanical fly ash collectors will be collected "dry" for disposal.

Fuel oil system will consist of a 50,000 barrel fuel oil storage tank, transfer pumps, fuel oil day tanks, and fuel oil pump and heater sets equipped with both electric and steam heaters.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

WOOD FUEL BOILER

Wood Fuel Boiler
- Boiler & Superheater
- Setting & Aluminum lagging
- Economizer & Soot Blowers
- Steam Coil Air Preheaters
- Oil Burning Equipment
- Chip Feeders & Distributors
- Overfire Air Blowers
- Traveling Grate
- Sand Classifiers
- Ash Sifting Hoppers

Fly Ash Collecting System

Chip Handling System

Ash Handling System

F.D. Fan & Motor Drive

I.D. Fan, Turbine Drive

Flues & Ducts

Fuel Oil System

Fuel Oil Storage Tank

SECTION 16

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

UTILITIES - BOILER PLANT AUXILIARIES

The makeup water demineralizer will consist of standard cation and anion ion exchangers with complete acid and caustic regeneration systems. No demineralized water storage tank will be furnished. Demineralized water will be pumped directly to the deaerator with makeup water pumps.

Deaerating feedwater heating equipment will consist of tray type deaerator and storage tank. Steam pressure will be 50 psig.

Boiler feed pumps will be horizontal split case type. Each pump will be sized for full capacity of both the recovery and wood fuel boilers combined. One pump will be motor driven, the other will be turbine driven.

Mill condensate will be collected and returned to the boiler system.

Chemical feed tanks and adjustable piston type feed pumps will be provided for both feedwater and boiler water treatment.

A standard continuous blowdown flash tank and makeup water heat exchanger system will be furnished. Flashed steam will go to the deaerator.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

BOILER PLANT AUXILIARIES

Demineralizer
Deareator
B.F. Pump - Motor Driven
B.F. Pump - Turbine Driven
Condensate Return Tank
Condensate Polishers
Chemical Feed System
Continuous Blowdown System
Air Compressors & Auxiliaries

SECTION 17

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

UTILITIES - DIESEL GENERATOR

The diesel generator will have an approximate capacity of 2,000 kW at 13,800 volts, and will initially be furnished for construction.

The diesel generator will be required to provide power to get the mill started.

After startup of the pump mill, the unit will be used for stand-by emergency power.

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

LIST OF MAJOR EQUIPMENT

UTILITIES - DIESEL GENERATOR

Diesel Engine
Generator
Diesel Oil System
Diesel Oil Storage Tank

SECTION 18

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

SHOPS & STORES - PULP MILL

The maintenance shops will be located on the ground floor and stores will be located on two floors with the ground floor area adjacent to the maintenance shops. Maintenance facilities will include machine, piping, millwright, sheet metal, insulation, electrical, instrument, welding, carpenter and paint shops.

The necessary machine tools and equipment will be provided to make the mill self-sufficient for its daily maintenance requirements, and most of its heavy major work.

All necessary work benches and bench equipment will be provided in convenient locations in the various shop areas.

Forklift truck maintenance will be done in the mobile equipment garage.

The storage area will have all of the necessary bins, cupboards and racks for storage of small stores spare parts and maintenance supplies, as well as hand tools and equipment. Heavy major capital spares will be stored in the maintenance storage building.

SECTION 19

MIXED TROPICAL HARDWOOD

500 T/D BLEACHED KRAFT PULP MILL

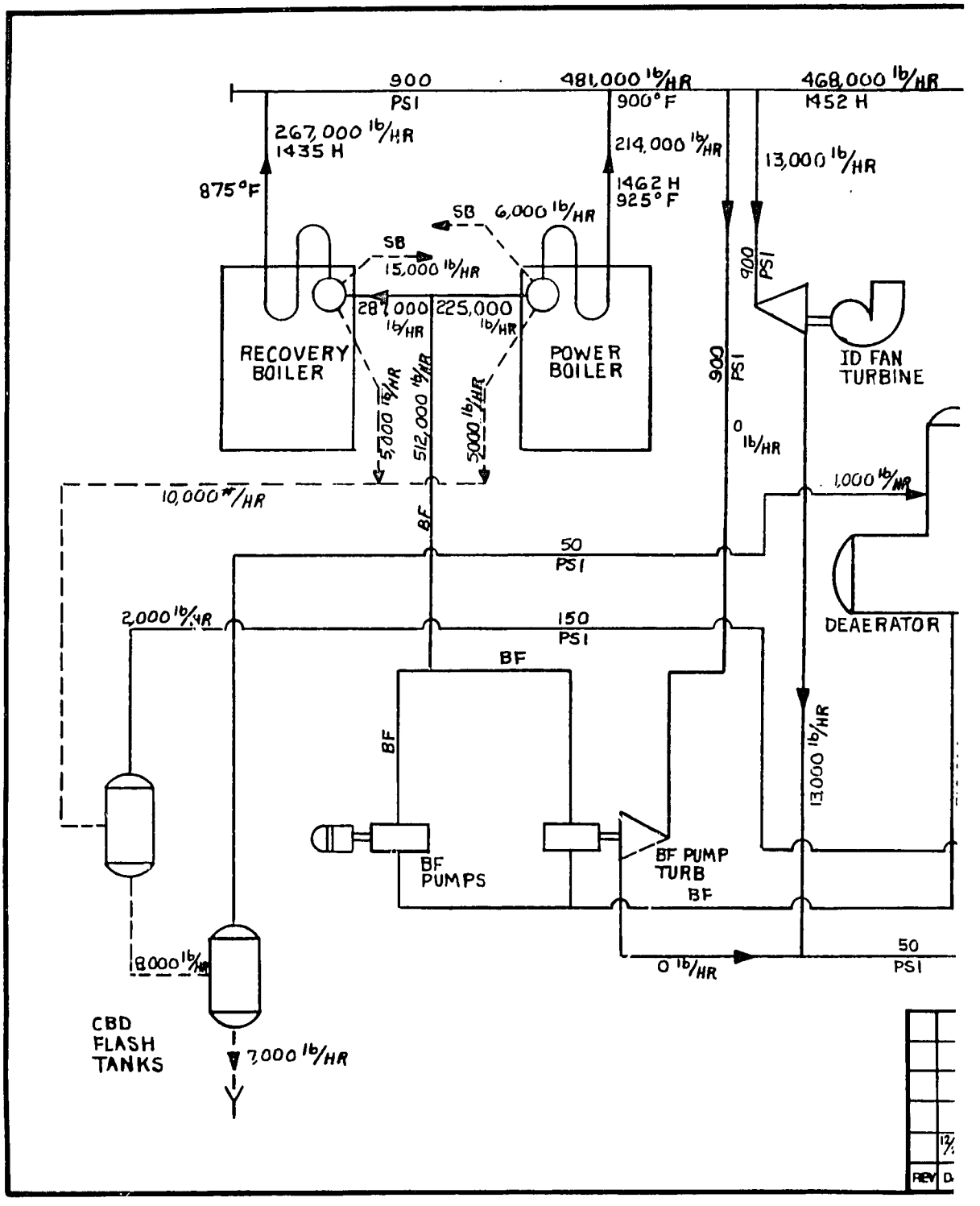
PERSONNEL FACILITIES

Offices and office space for administrative, staff and clerical personnel will be located in an office area adjacent to the mill block. Offices for supervisory personnel will be placed throughout the mill in appropriate locations.

A central laboratory for overall control testing along with offices will be located in the mill. Process control and product quality control testing will be performed in individual test stations located at suitable points throughout the mill.

Locker rooms, washrooms, lunch room, first aid room, engineering department and offices, maintenance offices, maintenance planning, and a large conference room will be located in the main mill. Local washrooms will be provided at various points in the mill.

Facilities for mill security and security forces will be provided at the mill entrance and local stations will be provided throughout the mill.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875°F
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925°F
13,000 lb/HR
SB
6,000 lb/HR
SB
15,000 lb/HR
900 PSI
281,000 lb/HR
225,000 lb/HR
RECOVERY BOILER
POWER BOILER
900 PSI
ID FAN TURBINE
5,000 lb/HR
512,000 lb/HR
5000 lb/HR
0 lb/HR
1,000 lb/HR
10,000 lb/HR
BF
50 PSI
DEAERATOR
2,000 lb/HR
150 PSI
BF
BF
13,000 lb/HR
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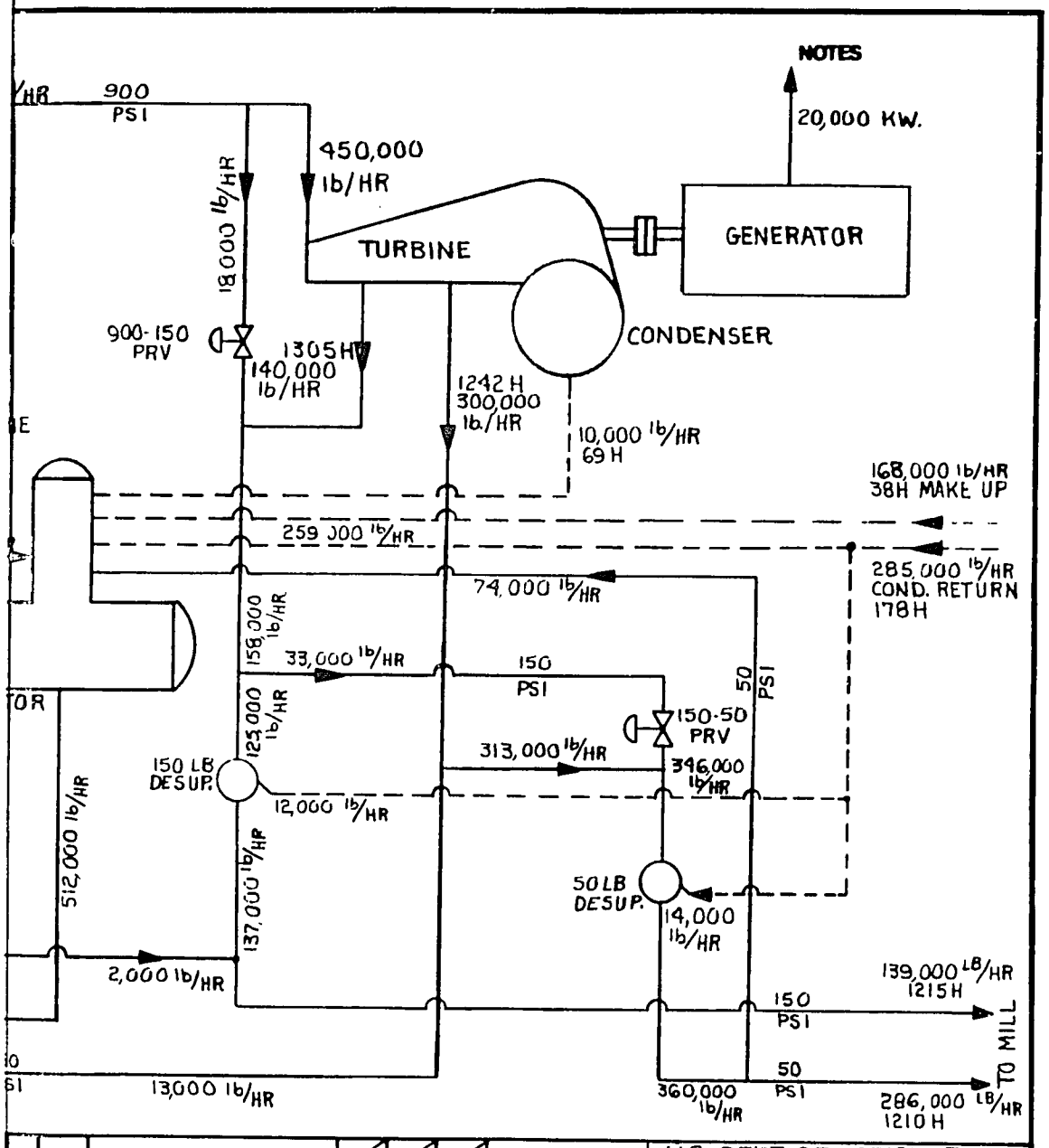
CBD FLASH TANKS
7,000 lb/HR
REV



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	12/20/77	REPORT						3254-1-0004

MAIN

U.S. DEPT. OF AGRICULTURE
FOREST PRODUCT LAB.
TROPICAL HARDWD UTILIZATION
500 T/D KRAFT PULP MILL
HEAT BALANCE

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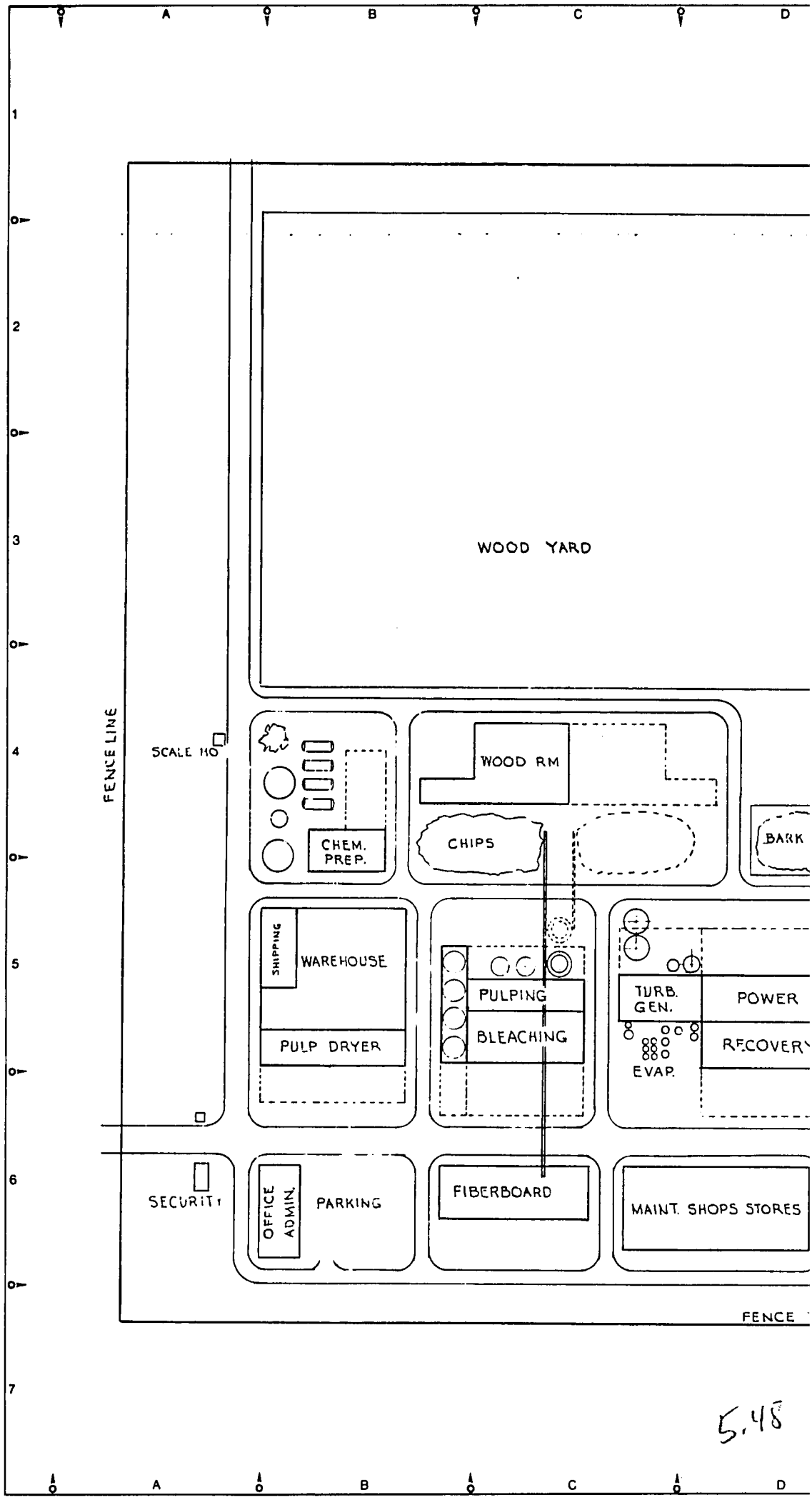
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WOOD YARD
FENCE LINE
SCALE HO
WOOD RM
CHIPS
CHEM. PREP.
BARK
SHIPPING
WAREHOUSE
PULP DRYER
PULPING
BLEACHING
TURB. GEN.
POWER
RECOVERY
EVAP.
SECURITY
OFFICE ADMIN.
PARKING
FIBERBOARD
MAINT. SHOPS STORES
FENCE

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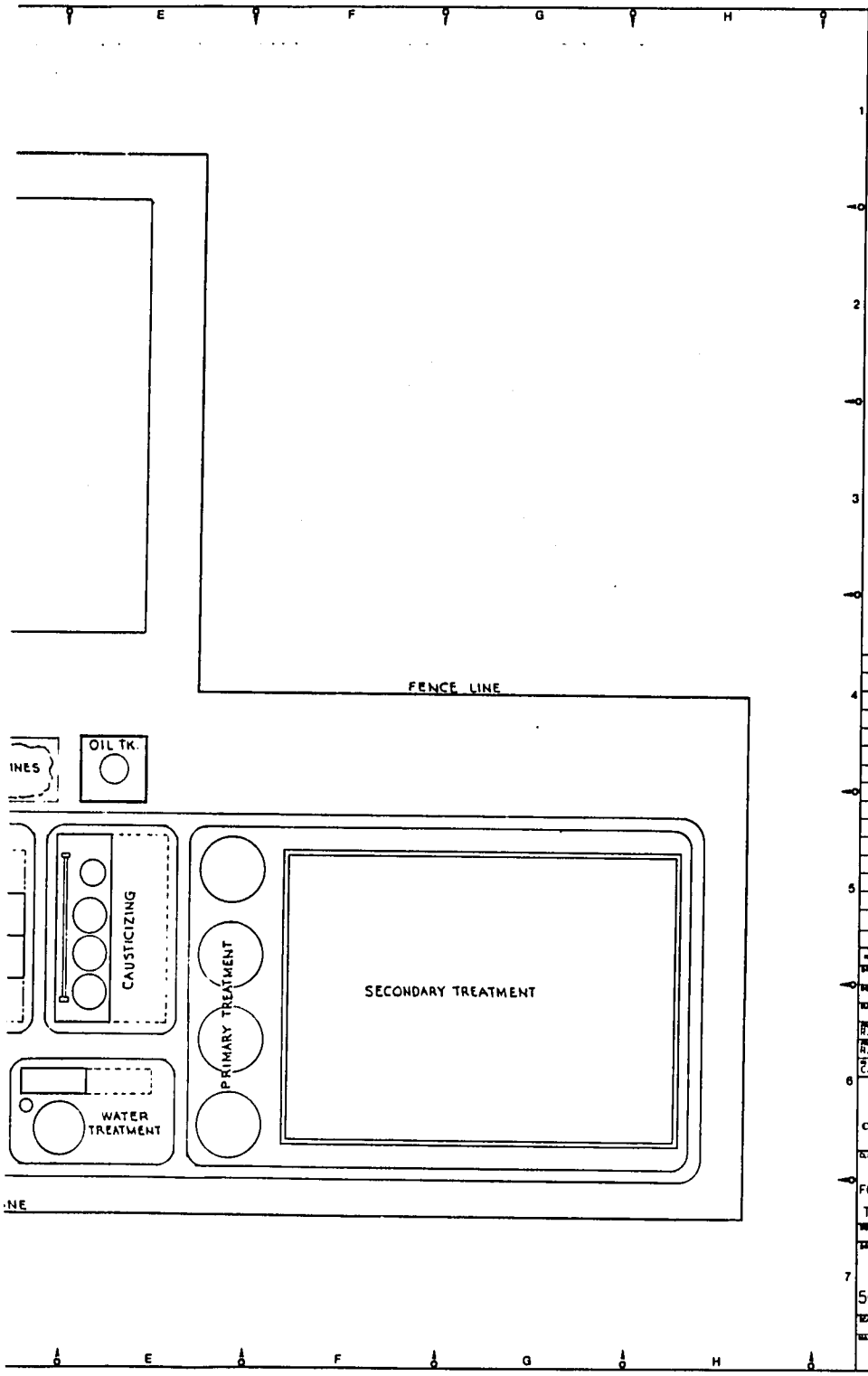

NOTES

REPORT

J.F. BURGIO

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C.D. BASSETT

MAIN

CHAS. T. MAIN INTERNATIONAL INC.

U.S. DEPT. OF AGRICULTURE
FOREST PRODUCTS LABORATORY
TROPICAL HARDWOOD UTILIZATION

PLANT ARRANGEMENT
500 T/D KRAFT PULP MILL

3254-1 0003

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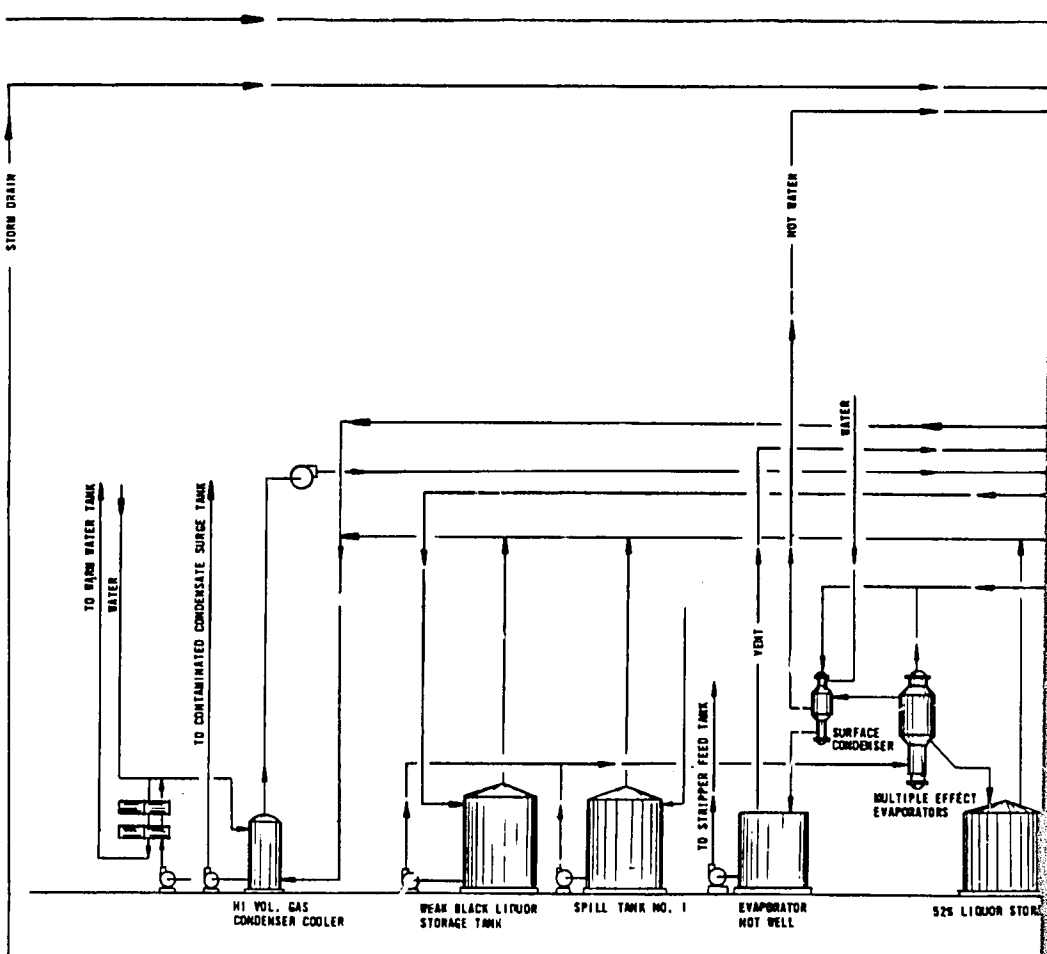
CHIPS TO DIGESTER

BARK AND CHIPS TO BOILER



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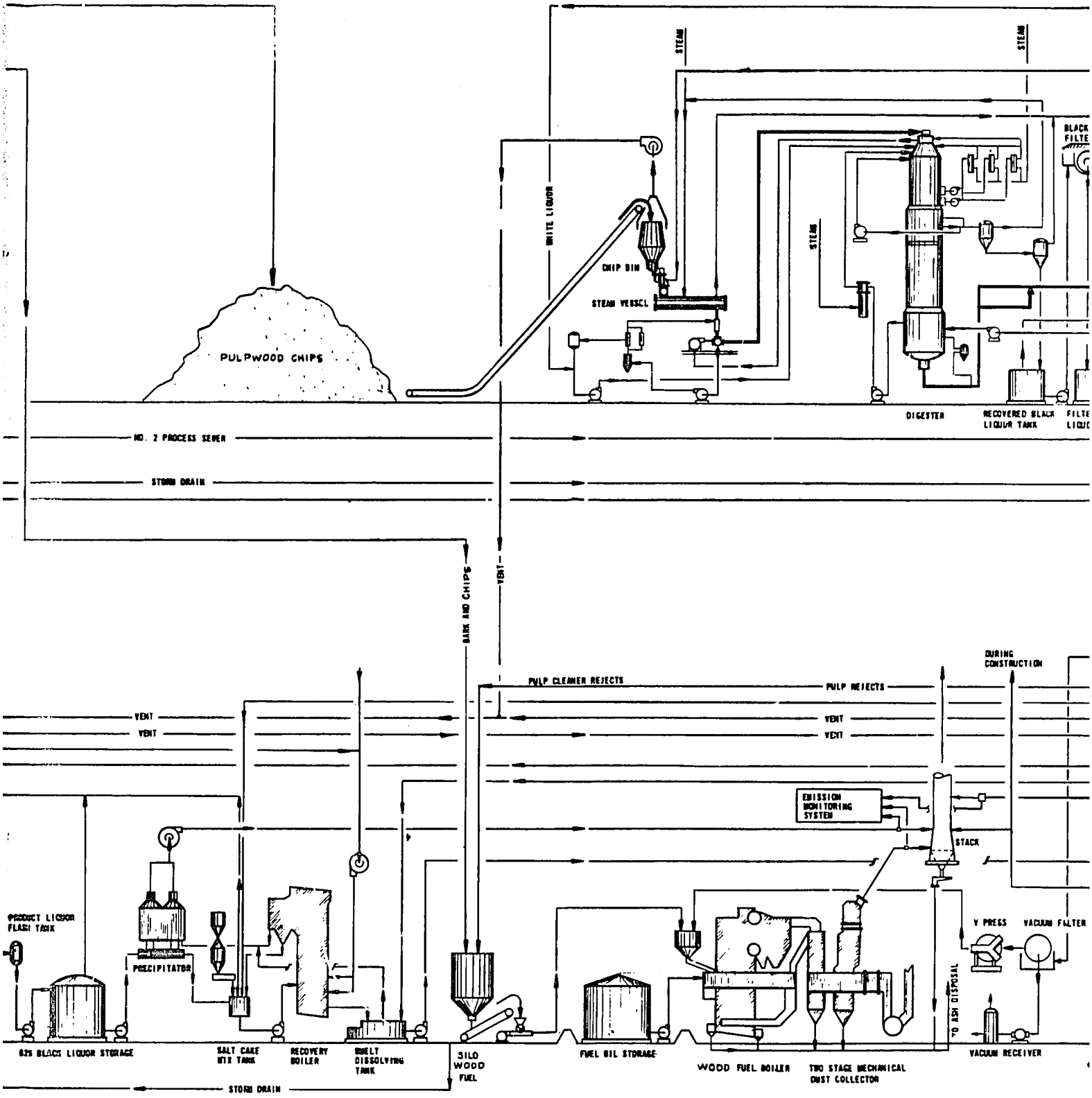
PULPWOOD CHIPS
WHITE LIQUOR
CHIP BIN
STEAM VESSEL
STEAM
STEAM
DIGESTER
RECOVERED BLACK LIQUOR TANK
NO. 2 PROCESS SEWER
STORM DRAIN
BARK AND CHIPS
VENT
PULP CLEANER REJECTS
PULP REJECTS
DURING CONSTRUCTION
VENT
VENT
VENT
VENT
EMISSION MONITORING SYSTEM
STACK
PRODUCT LIQUOR FLASH TANK
PRECIPITATOR
V PRESS
VACUUM FILTER
TO ASH DISPOSAL
62% BLACK LIQUOR STORAGE
SALT CAKE MIX TANK
RECOVERY BOILER
SMELT DISSOLVING TANK
SILO WOOD FUEL
FUEL OIL STORAGE
WOOD FUEL BOILER
TWO STAGE MECHANICAL DUST COLLECTOR
VACUUM RECEIVER
STORM DRAIN

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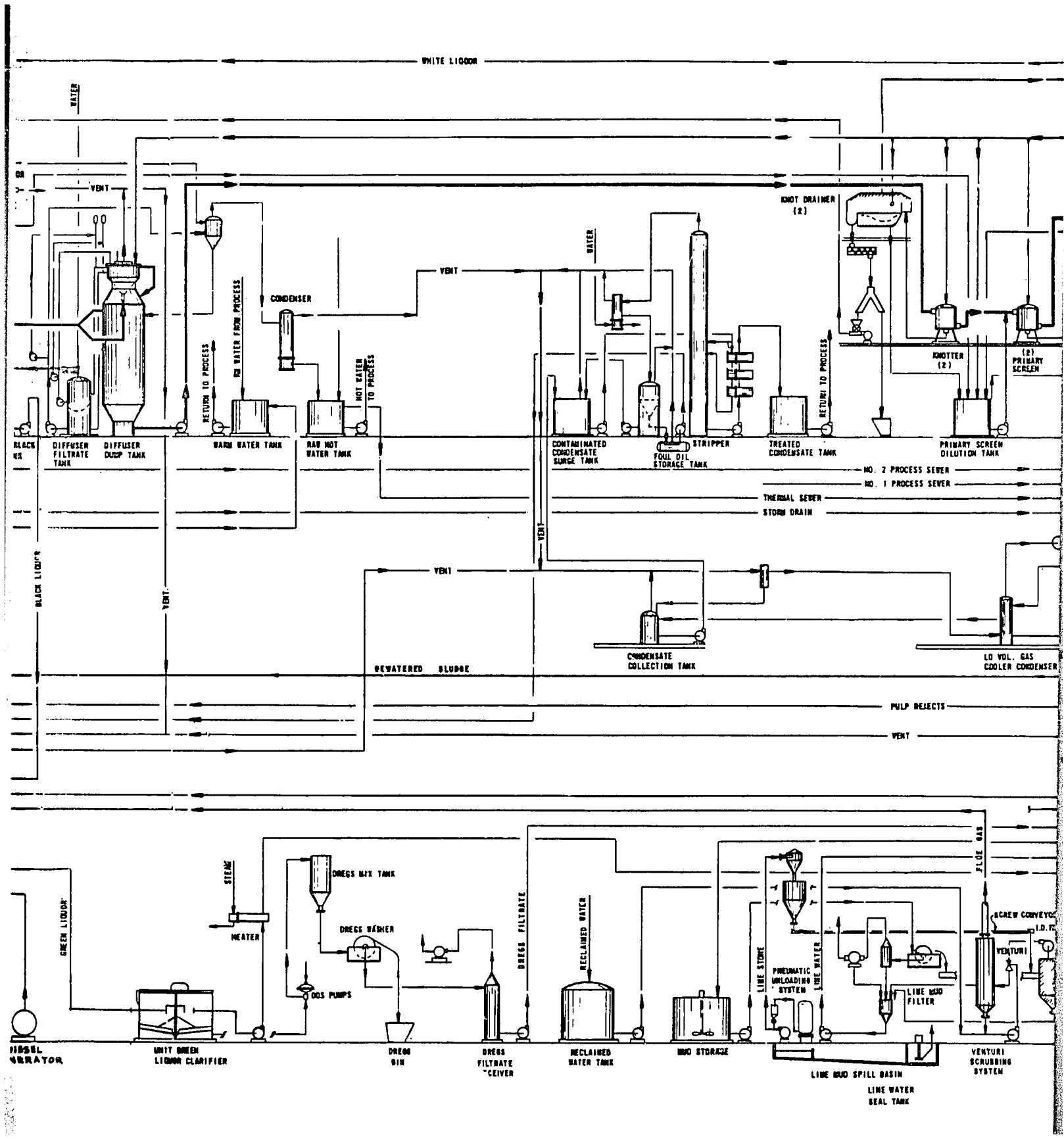
WHITE LIQUOR
WATER
OIL
VENT
CONDENSER
RETURN TO PROCESS
FOG WATER FROM PROCESS
HOT WATER TO PROCESS
DIFFUSER FILTRATE TANK
DIFFUSER DUMP TANK
WARM WATER TANK
RAW HOT WATER TANK
CONTAMINATED CONDENSATE SURGE TANK
FOUL OIL STORAGE TANK
STRIPPER
TREATED CONDENSATE TANK
KNOT DRAINER (2)
KNOTTER (2)
(2) PRIMARY SCREEN
PRIMARY SCREEN DILUTION TANK
NO. 2 PROCESS SEWER
NO. 1 PROCESS SEWER
THERMAL SEWER
STORM DRAIN
BLACK LIQUOR
CONDENSATE COLLECTION TANK
LO VOL. GAS COOLER CONDENSER
DEWATERED SLUDGE
PULP REJECTS
GREEN LIQUOR
STEAM
HEATER
DREGS MIX TANK
DREGS WASHER
DOS PUMPS
DREGS FILTRATE
RECLAIMED WATER
LIME STONE
PNEUMATIC UNLOADING SYSTEM
LIME WATER
LIME MUD FILTER
FLUE GAS
SCREW CONVEYOR
VENTURI
UNIT GREEN LIQUOR CLARIFIER
DREGS BIN
DREGS FILTRATE RECEIVER
RECLAIMED WATER TANK
MUD STORAGE
LIME MUD SPILL BASIN
LIME WATER SEAL TANK
VENTURI SCRUBBING SYSTEM

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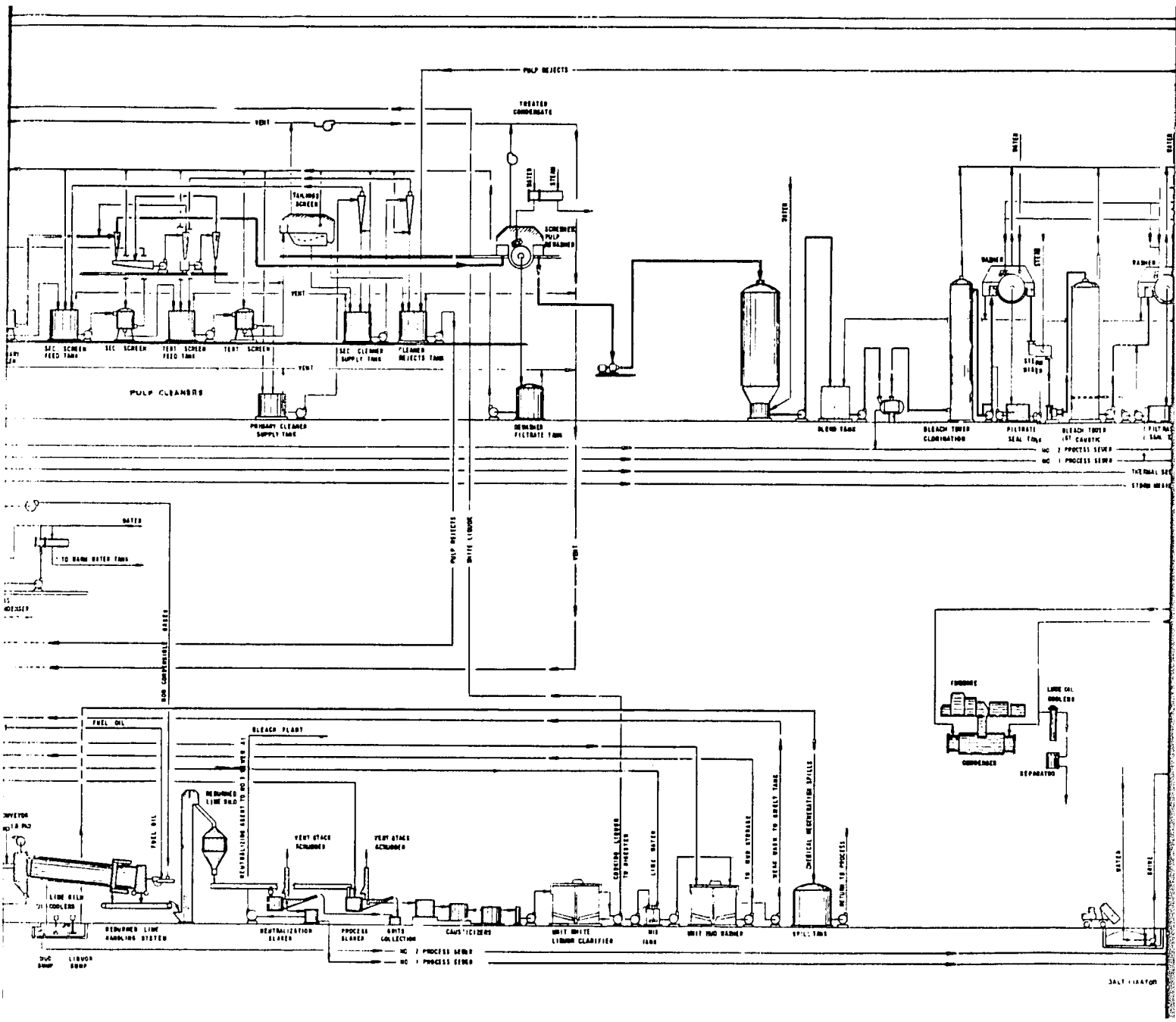
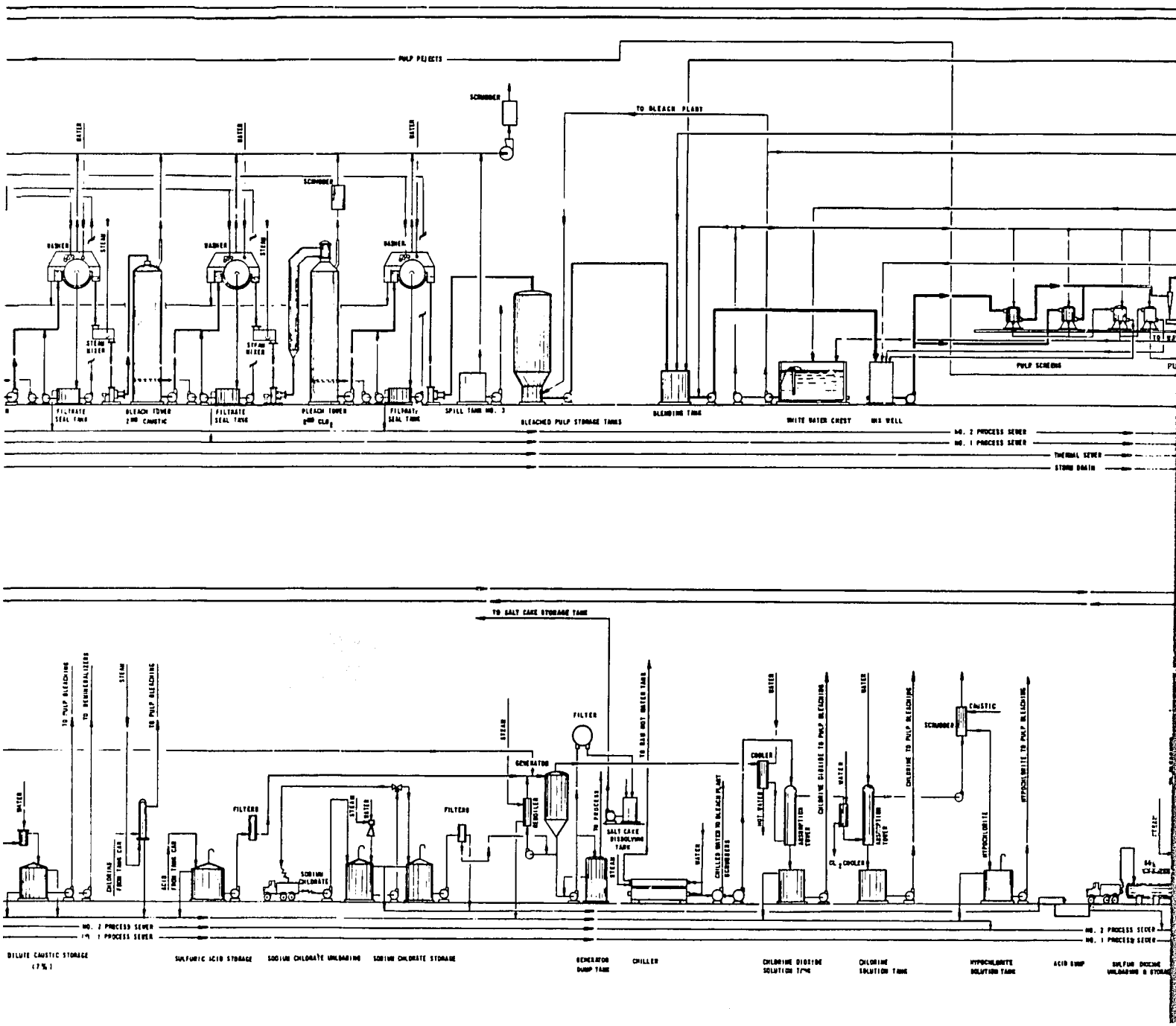
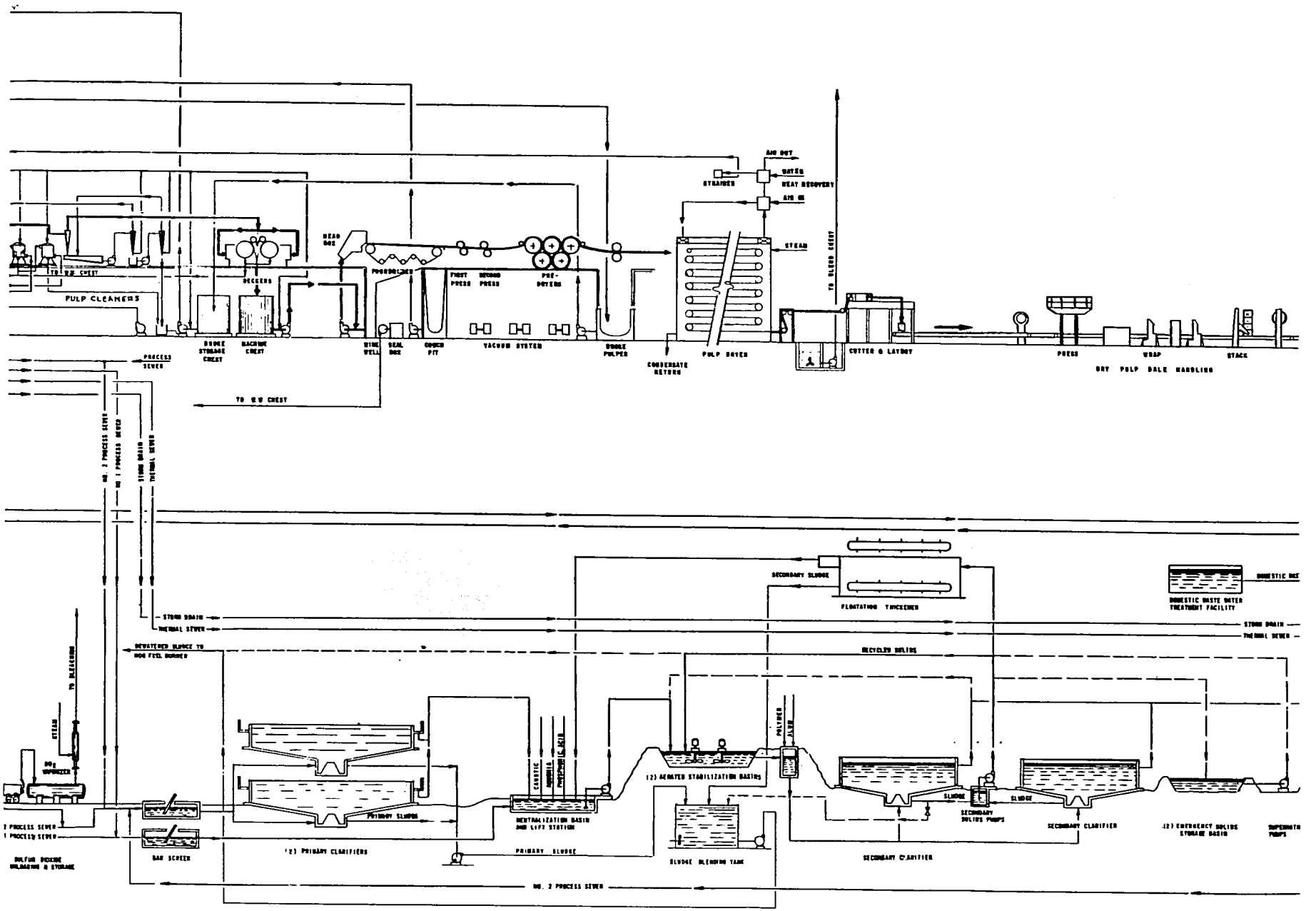

PULP REJECTS
TREATED CONDENSATE
VENT
WATER
STEAM
TAILINGS SCREEN
SCREENED PULP WASHER
SEC SCREEN FEED TANK
SEC SCREEN
TERT SCREEN FEED TANK
TERT SCREEN
SEC CLEANER SUPPLY TANK
CLEANER REJECTS TANK
PULP CLEANERS
PRIMARY CLEANER SUPPLY TANK
REWASHED FILTRATE TANK
BLEND TANK
BLEACH TOWER CLORINATION
FILTRATE SEAL TANK
BLEACH TOWER (2ND CAUSTIC
WASHER
NO 2 PROCESS SEWER
NO 1 PROCESS SEWER
TO WARM WATER TANK
WHITE LIQUOR
NON CONDENSIBLE GASES
FUEL OIL
BLEACH PLANT
REWASHED LIME MUD
NEUTRALIZING AGENT TO BLEACH PLANT
VENT STACK SCRUBBER
CAUSTICIZER TO DIGESTER
LIME WATER
TO MUD STORAGE
WEAK WASH TO GREEN TANK
CHEMICAL RECUPERATION SPILLS
RETURN TO PROCESS
CONDENSER
LIME OIL COOLERS
SEPARATOR
LIME KILN COOLERS
REWASHED LIME HANDLING SYSTEM
NEUTRALIZATION SLAKER
PROCESS SLAKER
GRITS COLLECTION
CAUSTICIZERS
WHITE LIQUOR CLARIFIER
MUD TANK
WHITE MUD WASHER
SPILL TANK
DUST SUMP
LIQUOR SUMP
BRINE


PULP REJECTS
SCRUBBER
TO BLEACH PLANT
WATER
STEAM
WASHER
STEAM MIXER
FILTRATE SEAL TANK
BLEACH TOWER
2ND CAUSTIC
PLEACH TOWER
SPILL TANK NO. 3
BLEACHED PULP STORAGE TANKS
BLENDING TANK
WHITE WATER CHEST
MIX WELL
PULP SCREENS
NO. 2 PROCESS SEWER
NO. 1 PROCESS SEWER
THERMAL SEWER
STORM DRAIN
TO SALT CAKE STORAGE TANK
TO PULP BLEACHING
TO DEMINERALIZERS
FILTER
GENERATOR
MERCILLER
TO BAND HOT WATER TANK
TO PROCESS
SALT CAKE DISSOLVING TANK
CHILLER WATER TO BLEACH PLANT SCRUBBERS
COOLER
HOT WATER
ABSORPTION TOWER
CHLORINE DIOXIDE TO PULP BLEACHING
CHLORINE TO PULP BLEACHING
CAUSTIC
HYPOCHLORITE TO PULP BLEACHING
HYPOCHLORITE
FILTERS
SODIUM CHLORATE
CHLORINE FROM TANK CAR
ACID FROM TANK CAR
DILUTE CAUSTIC STORAGE (7%)
SULFURIC ACID STORAGE
SODIUM CHLORATE UNLOADING
SODIUM CHLORATE STORAGE
GENERATOR DAMP TANK
CHILLER
CHLORINE DIOXIDE SOLUTION TANK
CHLORINE SOLUTION TANK
HYPOCHLORITE SOLUTION TANK
ACID SUMP
SULFUR DIOXIDE UNLOADING & STORAGE

5.49d


PULP CLEANERS
TO H.D. CHEST
DECKERS
STORAGE CHEST
MACHINE CHEST
HEAD BOX
FOURDRINIER
WIRE WELL
SEAL BOX
COUCH PIT
FIRST PRESS
SECOND PRESS
PRE-DRYERS
VACUUM SYSTEM
DOUBLE PULPER
CONDENSATE RETURN
PULP DRYER
STEAMER
AIR OUT
WATER
HEAT RECOVERY
AIR IN
STEAM
TO BLOW SHOT
CUTTER & LAYDOWN
PRESS
WRAP
STACK
DRY PULP BALE HANDLING
PROCESS SEWER
TO H.D. CHEST
NO. 2 PROCESS SEWER
NO. 1 PROCESS SEWER
STORM DRAIN
THERMAL SEWER
SECONDARY SLUDGE
FLOTATION THICKENER
DOMESTIC WASTE WATER TREATMENT FACILITY
DOMESTIC OUT
STORM DRAIN
THERMAL SEWER
DEWATERED SLUDGE TO HOG FUEL BURNER
RECYCLED SOLIDS
TO BLEACHING
STEAM
SO2 VAPORIZER
CAUSTIC
AMMONIA
PHOSPHORIC ACID
POLYMER
ALUM
(2) AERATED STABILIZATION BASINS
PRIMARY SLUDGE
NEUTRALIZATION BASIN AND LIFT STATION
SLUDGE
SECONDARY SOLIDS PUMPS
SECONDARY CLARIFIER
(2) EMERGENCY SOLIDS STORAGE BASIN
SUPERNATANT PUMPS
1 PROCESS SEWER
1 PROCESS SEWER
SULFUR DIOXIDE UNLOADING & STORAGE
BAR SCREEN
(2) PRIMARY CLARIFIERS
PRIMARY SLUDGE
SLUDGE BLENDING TANK
SECONDARY CLARIFIER
NO. 2 PROCESS SEWER

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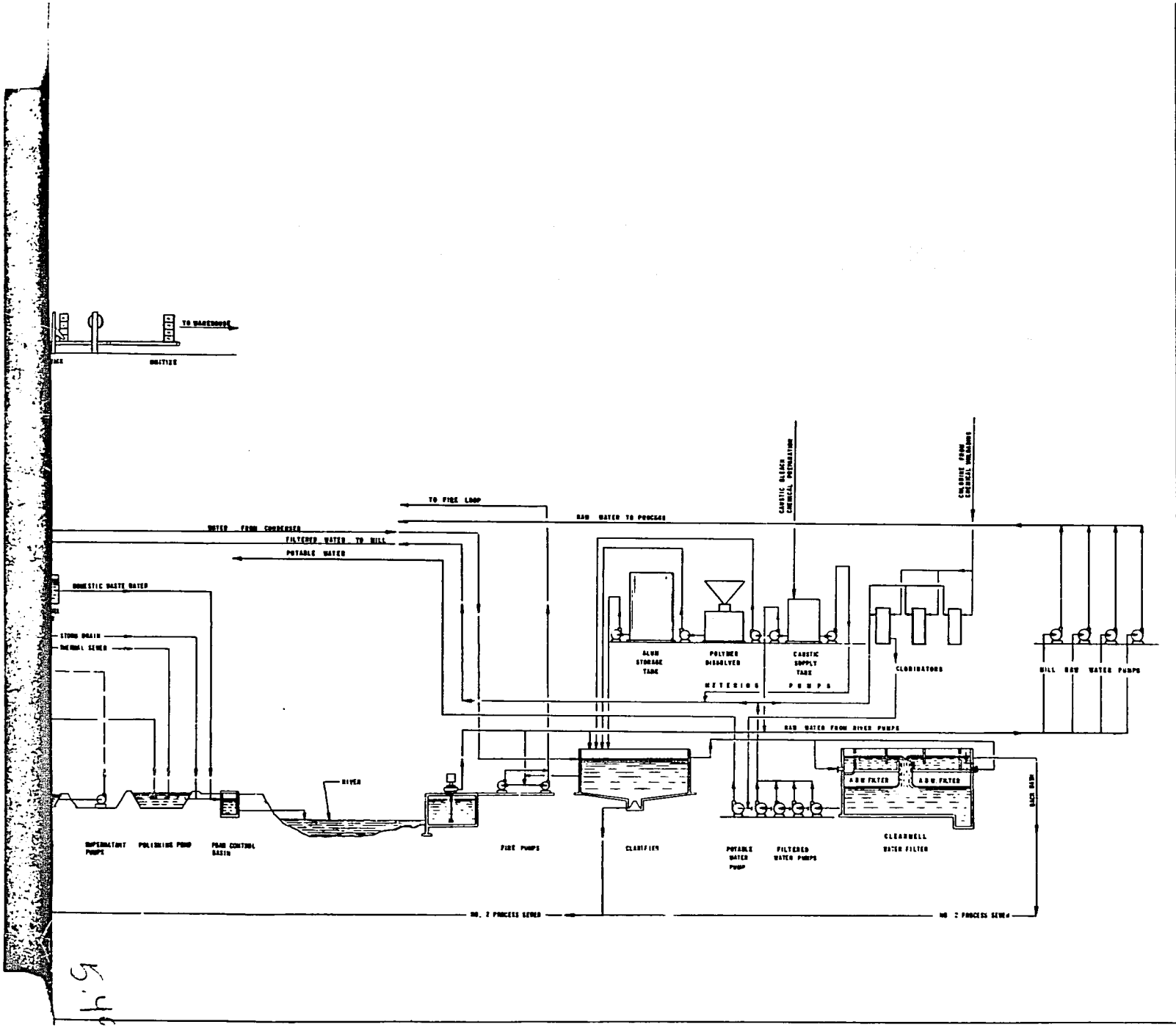

NO	DATE	DESCRIPTION
		REPORT

DRAWN BY

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IN CHARGE
C. D. BASSETT

MAIN

CHAS. T. MAIN INTERNATIONAL, INC.

CLIENT/PROJECT TITLE
U.S. DEPT. OF AGRICULTURE
FOREST PRODUCTS LABORATORY
TROPICAL HARDWOOD UTILIZATION

DRAWING DESCRIPTION
PROCESS FLOW DIAGRAM
500 T/D KRAFT PULP MILL

SCALE

MAIN DWG NO
3254 - 1 0001

REV.

Fig. 4

U.S. DEPARTMENT OF AGRICULTURE
FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

LOCATION OF MILL - AFRICA
SOUTH AMERICA

The principal emphasis of this report was on the study of a hypothetical mixed tropical hardwood pulp mill located in Southeast Asia. The requirments of this survey call for a notation only, of the significant differences for a mixed tropical hardwood mill located in South America or in Africa. The countries selected were: Colombia, South America; and Ghana, Africa.

It has been determined that mixed tropical hardwoods are available in these locations, and that this wood can be used to produce acceptable quality bleached kraft pulp. This determination has been made through laboratory and pilot scale tests at U.S. Forest Products Laboratory of wood from Colombia and Ghana; and from commercial operations in Colombia.

In order to accurately evalute the significant differences, it is essential that a specific site be selected and a detailed study be made. Using the Southeast Asian Mill as a base case, however, the following generalizations can be made.

A. Colombia. -
- The infrastructure is better developed.
- An international market presently exists for pulp from South American tropical hardwoods.
- The pulp mill supervisors will have had prior exposure to the pulp and paper industry.
- The pulp mill will be more technologically advanced in design.
- Equipment costs will be lower, construction costs will be higher.

- Operating costs will be lower, due in part, to the government subsidy of oil.

B. Ghana. -

- The infrastructure is less well developed.
- Little is known commerically concerning pulp from African tropical hardwoods.
- Training and education requirements would be much more extensive.
- A larger expatriate labor force would be required to startup and operate the mill. Expatriate management and labor would be required for a longer period of time.
- The general exposure to technology is much lower, therefore, a less sophisticated pulp mill design is indicated.

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PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOOD UTILIZATION

IMPACT OF THE USE OF MIXED TROPICAL HARDWOODS TO AN EXISTING MILL

The impact of using mixed tropical hardwood to an existing mill may be assessed on the following five bases:

1. Impact on Pulp Quality and Marketability

2. Impact on Production Rate

3. Impact on Capital Costs

4. Impact on Operating Costs (Fuel Cost)

5. Impact on Optimization

1. Impact on Pulp Quality and Marketability

These have been dealt with previously in this study. Summarizing that information, it was stated that quality will be comparable to single species hardwood pulps for certain grades of paper. In the case of an existing mill, some initial price discounting may be necessary to satisfy present customers.

2. Impact on Production Rate

In order to maintain production rate when mixed tropical hardwood is used for pulping, (in a kraft pulp mill of traditional design for temperate zone hardwoods) and wood is substituted for oil in the power boiler, the following new design conditions must be considered:

A. Wood harvesting requirements increase by 35%. This results from the use of more wood for pulping to a lower yield; and the requirement to harvest wood for use as fuel. A detailed study would be needed to determine the net additional land required after credit is given for run-of-the-woods harvesting which would be used for mixed tropical hardwood.

B. Wood processing requirements increase to handle the incoming roundwood. Fuel wood does not require debarking or screening. However, three times the wood and waste handling to the boiler is required.

C. Pulp digester, evaporation, recovery boiler and liquor preparation system requirements increase by 10% to 15% to maintain the original unbleached pulp production rate. Most mixed tropical hardwoods have a higher percentage of non-celulosic organics than North American hardwood, therefore, a lower unbleached yield results. All processing areas affected by this must be sized accordingly. The requirements in these areas would be dependent upon the actual raw materials in a specific location.

D. Centrifugal cleaning system is recommended. Mixed tropical hardwoods generally have a high resin content, and these resins are not easily saponified. Unbleached pulp cleaners can be used to aid in the removal of this pitch.

3. Impact on Capital Costs

It can be seen from Item 2 above, that a specific mill must be studied in order to determine limitations imposed on total mill production. After evaluating the capacity limitations of each major production system, the capital costs of overcoming the limitations can be considered.

A. Woodlands must be reviewed and a determination must be made concerning long term sustainable yield.

B. Wood processing capacity can generally be increased incrementally.

C. A mill with batch digesters can be increased in size by increments, however, a continuous cooking system will require a more careful study. Evaporator systems can usually be increased by increments. The liquor preparation system consists of many components. Capacity can often be increased by adding components and making design changes or by accepting lower efficiency. A brown stock centrifugal cleaning system can be added, however, additional thickening capacity may also be needed.

D. Recovery Boiler. After a determination has been made of the increased liquor flow anticipated, this unit must be evaulated for maximum liquor incineration and steam generating capabilities. If the unit was conservatively designed for the original conditions, it will be possible to fire the additional liquor, generate more steam, and still meet the applicable codes. If the unit is operating at or near its rated capacity, it will not be possible to generate any more steam. The additional liquor, however, may be fired using the furnace as a smelter furnace. This will result in

additional particulate matter to the electrostatic precipator and will require the addition of a new electrostatic precipator operating in series. In this case, a black liquor oxidation system would also be required.

E. Power Boiler. The combustion components of this unit will be dramatically affected by the substitution of wood for fuel oil. A larger traveling grate must be added to burn the additional wood. The addition of this grate could result in the following major changes:

1. Change of furnace size. To keep steam production the same as that when firing oil, a grate larger in area than the furnace must be installed. This means major modifications to the furnace including replacement of the bottom and front wall and enlargement of the side walls.

2. Change in combustion air requirements. Complete new and larger combustion and overfire air systems must be designed in order to burn the wood. This would result in the installation of a new forced draft fan.

   Converting from fuel oil to 80% wood for fuel increases the problem of particulate collection at the outlet of the boiler. Investigations must be made to determine the type of systems to be used in order to meet applicable codes for particulate emissions. These could consist of mechanical collectors, scrubbers, electrostatic precipitators, or any combination of the three. The addition of of this equipment will require the installation of a new induced draft fan.

In order to burn the additional wood as a fuel, a larger wood handling system must be designed and furnished to convey the wood to the furnace to be burned and an expanded ash handling system must be designed and furnished to dispose of the collected bottom ash and collected particulate matter.

Conversion to 80% wood firing is a major project and would require a lengthly shutdown of the power boiler. This would require a temporary source of steam supply, such as a package boiler, during the progress of the work.

An alternate and far more costly course of action is the installation of a new unit sized for the changed conditions. Although modification to the existing power will be expensive, the total cost will nevertheless be lower than that for a new installation.

4. Impact on Operating Costs

The major impact on operating costs would result from the substitution of fuel wood for fuel oil in the wood fuel power boiler.

The annual operating cost savings based on the costs of wood and fuel oil established in this report would be in the order of:

*	$ 830,000	for a 100 T/D Pulp Mill
	$1,660,000	for a 200 T/D Pulp Mill
	$2,490,000	for a 300 T/D Pulp Mill

* Fuel Costs - Wood fuel boiler vs standard boiler

Hardwood Mill:

Fuel Oil	10 292 Gal/Day @$.454/Gal =	$ 4,675/Day
Bark	26.3 T/D byproduct of pulping	

Mixed Tropical Hardwood Mill w/Wood Fuel:

Fuel Oil	1969 Gal/Day @$.454/Gal = $890/Day	$ 2,307/Day
Bark	30 T/D byproduct of pulping	
**Fuel Wood	55.3 T/D @ $25.62/T = $1417/Day	

Savings Using Wood Fuel	$ 2,368/Day
Savings Using Wood Fuel	$828,800/Year

**Fuel Wood - Cost/Ton

Fuel Wood Cost/M^3 = $13.55 (Information from H.C. Mason, Section 3)

$$\frac{\$13.55}{M^3} \cdot \frac{M^3}{35.314\ FT^3} \cdot \frac{FT^3}{62.4\ (.48)\ LB} \cdot \frac{2000\ LB}{Ton} = \$25.62/Ton$$

5. Impact on Optimization

The alternative courses of action are:

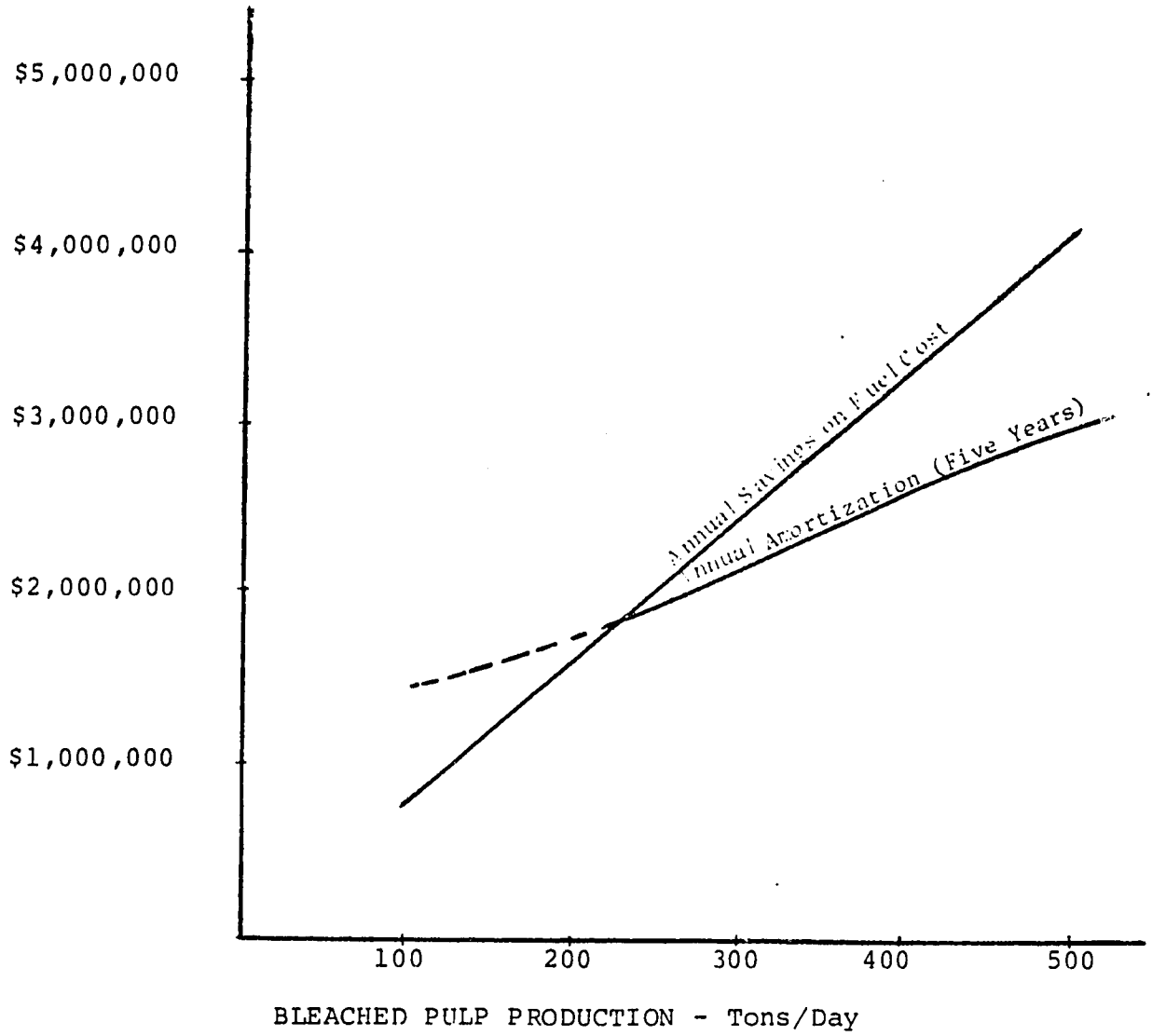
A. Invest the necessary capital to increase capacity of processing areas as required to match the capacity of the rest of the mill.

B. Reduce production until limiting processing areas can keep up with mill production.

The optimum course of action is found at that point where profit is maximized.

An example is presented to indicate the annual cost vs annual savings for a 500 T/D mill in which a new wood fuel boiler is required and the total capital cost for conversion to wood fuel is $15,000,000. This may also be used to show the relative cost vs savings to install comparable equipment in mills of smaller size. The example shows that costs balance savings (during the five year amortization period) for a 225 T/D mill.

ANNUAL SAVINGS vs. ANNUAL COSTS



Assume: 500 T/D Bleached Pulp Mill
$15,000,000 Capital Investment required
5 Year Amortization period

Saving would equal $1,000,000 annually for 5 years, then increase to $4,150,000 thereafter.

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FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

FIBERBOARD MANUFACTURE

INTRODUCTION

The Forest Products Laboratory specification requested that a 100 T/D fiberboard or particle board mill be included in the study with the 500 T/D pulp mill. A wet process fiberboard operation has been chosen for this presentation. A wide range of wood density and color is tolerable in fiberboard manufacture resulting in high utilization of the wood species available. From a marketing point of view, fiberboard has more flexibility than particleboard. By use of different wood densities, different products can be made, ranging from insulation to medium density fiberboard, to hardboard. In addition, fiberboard is more suitable for export markets due to the lighter weight product which results.

LABORATORY RESULTS

Tests were made at the Forest Products Laboratory in Madison, Wisconsin to note the effect of wood density on the quality of the board and to study the use of screen rejects from the chipping operation as a raw material for fiberboard. The formed boards were made with chip mixtures of light and heavy densities and with chips of heavy densities only. The boards made from both density groups met the product standard requirements for the product properties evaluated, indicating that high density woods are as suitable for fiberboard manufacture as the mixed group.

The fiberboard operation allows selective use of these woods, which may not be suitable for pulping. The use of 100% chip screen rejects for hardboard produced a substandard board. The rejects used were a mixture of both oversized and undersized material. The board which resulted was lower in bending and tensile strength than board produced with a chip mixture. Blending of screen rejects and chips in equal amounts by weight gave some improvement but not enough to meet the produce standards.

Indications from these tests are that if screenings are used, they must be used at a limited percentage of the total wood furnish in order to produce an acceptable board.

The general conclusions of the tests at the Forest Products Laboratory are that tropical hardwoods can be converted to good quality pressurized refined pulp for use with hardboards manufacture, and that different hardwood mixtures can be used with minimal effect on board quality.

U. S. DEPARTMENT OF AGRICULTURE
FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

FIBERBOARD MANUFACTURE

DESCRIPTION OF OPERATION

General

The fiberboard plant is envisioned as a part of the pulp mill complex. As such, it has been considered not to require an infrastructure cost. In addition it has available from the pulp mill complex enough water, steam, electric power and waste treatment capacity for the operation. Another benefit considered is that chips for the fiberboard operation will be prepared in the pulp mill operation, and no costs of wood handling and storage or chips processing and storage are included in the fiberboard and plant cost. Waste wood from the pulping operation will be utilized wherever possible.

Fiberboard Process

Screened chips are blown from the common chip pile to the fiberboard plant chip bin supplying the fiberizing unit, where they are metered into a steaming vessel. Steaming at temperatures in the range of 150 to 180°C moistens and softens the chips for the subsequent defiberizing unit. Chips are then fed, still under pressure, in a refiner which reduces them to a fibrous pulp. The pulp is blown under pressure to a cyclone where further disintegration takes place and the pulp is diluted with water

and discharged to a storage chest. Pulp freeness is controlled for the desired product.

Chemicals are added to give the board the desired characteristics. Aluminum sulfate is added for pH control and paraffin wax is generally added to improve water resistance. Synthetic resin is sometimes added to improve internal bond and weather resistance, but it is not absolutely required in the wet fiberboard process. To minimize manufacturing costs, it is assumed that no resin is required in the board to be manufactured in this study.

Consistency is adjusted to about 1.2 to 1.5% and the stock is pumped to the headbox of a sheet forming machine. For the boards to be manufactured in this study, it is assumed that no screening of the stock is required. The stock is dewatered on a fourdrinier type former and then pressed to remove additional water. The fiber mat at about 30% consistency is discharged to a roll table where a traversing saw cuts the mat into sheets of predetermined length.

The sheets are fed into wire frames to form a multi-tiered rack, which is entered into a hydraulic press and dried at about 180 to 200°C under pressure. The sheets may be given a decorative surface pattern in this operation. The caliper of the mat is reduced, and the density of the board increased to suit product requirements. The press heat is supplied by steam from the pulp mill boiler.

After press-drying the boards are sent to a heat treating operation to improve strength and water resistance, and then to a humidifying chamber for conditioning to improve dimensional stability.

The boards are transferred to roll tables where trimming saws cut the sheets to size as required for the end use.

Board packing and crating facilities, warehousing and shipping facilities are included.

For this study, it is assumed the board will be marketed without further finishing, although subsequent operations may be added in the future for speciality grades.

SCHEDULE

For planning purposes, a period from 18 months to two years may be assumed from the start of purchase of equipment until the startup of the operation.

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FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

FIBERBOARD MANUFACTURE

Data Sheet

Product	Hardboard for building industry and furniture
Board Caliper	3.2 - 6.0 mm
Board Density	800 - 1,000 kg/m^3
Operating Capacity	100 T/D average basis: 3.2 mm thick and 1000 kg/m^3 density
Design Capacity	120 T/D
Wood	1.15 tons wood/tons board
Chemicals	
Paraffin wax	10 kg/ton board
Aluminum sulfate	10 kg/ton board
Electrical	600 - 650 kWh/ton board
Steam	2.4 - 2.8 x 10^6 Kcal/ton board
Water	10 - 20 m^3/ton board
Manpower	
Skilled	40 - 50
Semi-skilled	20 - 30
Unskilled	20 - 30
Total	80-110

MAIN

MIXED TROPICAL HARDWOOD STUDY

100 T/D FIBERBOARD MILL

LIST OF MAJOR EQUIPMENT

DEPARTMENT 1 - CHIP TRANSPORT AND STORING

Item No.

1. High pressure pneumatic system, consisting of:

   Blower with fittings and V-belt drive
   Inlet silencer with filter
   Discharge silencer
   Control panel
   Pipes for pneumatic conveying and cyclone

2. Chip bin above the defibrator

DEPARTMENT 2 - DEFIBRATION AND PULP PREPARATION

Item No.

1. Defibrator system consisting of a screw feeder and preheater, defibrator, blow valve, piping to cyclone, cyclone, and discharge piping, motors and controls

2. Pulp storage chest including agitators, pumps and motors

3. Level box for pulp

4. Level box for white water

5. Pumps and motors for stock and white water for wet forming

DEPARTMENT 3 - CHEMICAL PREPARATION

Tanks, agitators, pumps, motors and controls for wax, alum and other chemicals.

DEPARTMENT 4 - WET FORMING

Item No.

1. Wet forming machine system consists of the following main parts:

   Based on manufacturing of 3.2 mm thick hardboard -

Trim width:	1250 mm
Capacity:	125 t/24 h
Inlet cons.:	1.3%
Machine speed:	8-24 m/min.

   Headbox
   Suction box section
   Press section
   Traversing cross cut saw
   Sole plates and frame work
   Hydraulic and pneumatic control equipment
   Vacuum equipment
   Mechanical drive, motors, piping and controls

2. Manually operated overhead crane with one chain hoist, 5000 kgs, and one chain hoist, 2000 kgs

DEPARTMENT 5 - PRESSING

Item No.

1. Hydraulic press system:

Press force:	3,400,000 kgs
Hydraulic working pressure max.:	260 kgs/sqcm
Number of cylinders:	3
Number of heating platens:	31
Length of heating platens:	5100 mm
Width of heating platens:	1380 mm
Specific pressure on the wet laps approx.:	50 kgs/sqcm

System consists of press hydraulic system, pumps, motors, piping and controls.

2. Feeding and discharge system for the press, including conveyors, loader, unloader, frames and screens, and screen washing system, piping, motors, and controls

3. Press heating system

DEPARTMENT 6 - HEAT TREATMENT AND HUMIDIFICATION

Item No.

1. Transport system for sheets from hydraulic press to transport wagons

2. Wagons and transfer trucks

3. Heat treatment and humidification plant consisting of:

   Six sets of mechanical equipment for one-wagon heat treatment plate chambers, each provided with one propeller fan, heating coils, sprinkler and cooling nozzles instruments, and motors

   Six sets of mechanical equipment for two-wagon humidification concrete chambers, each provided with one propeller fan, water eliminators, water boxes, instruments, and motors

DEPARTMENT 7 - BOARD TRIMMING

Item No.

1. Transport sysetm for sheets from transport wagons to board trimming

2. Board trim saw unit

3. Trimming saw unit for off-size board sheets

DEPARTMENT 8 - PACKING AND CRATING

Item No.

1. Fork lift diesel engine truck
2. Storage wagons
3. Strapping machines

DEPARTMENT 9 - LABORATORY

Testing apparatus for pulp and board, and general laboratory facilities

DEPARTMENT 10 - REPAIR SHOP

Machinery and tools for general maintenance

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PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

FIBERBOARD PLANT
IN
PULP MILL COMPLEX
CAPITAL COST ESTIMATE

GENERAL

The capital costs presented in this report are generally based on information supplied by Defibrator Fiberboard AB for process and equipment representative of installations proposed for developing countries.[1,2] Obviously, many variations in approach are possible, so this study information should be regarded as preliminary only.

Costs for equipment are based on a Defibrator proposal to a developing country. Adjustments to their prices have been made to reflect differences in their system and the one presented in the report. In addition, costs have been adjusted to reflect inflation from the time of the proposal to the date of this report. No costs are included for spare parts.

CIF costs, local handling and transportation costs, and costs for associated materials and systems have been estimated based on MAIN's experience. Costs of structures and installation of equipment have been estimated also in accordance with MAIN's experience in Southeast Asia.

Allocations have been made for startup costs, working capital, and interest on capital. Startup costs are based on training plant personnel and on having experienced personnel aid in the early operation of the plant. Working capital needs are based on raw

material and finished goods inventory plus receivables. Interest on capital is based on 60% debt ratio at 12% interest.

Costs are based on fourth quarter 1977, and no provision for inflation beyond that time is included.

As previously described, the capital cost estimate reflects the fact that the fiberboard mill is located within the pulp mill complex, and therefore, requires no separate costs for infrastructure, electric power generation, steam generation, water supply and effluent treatment. It is not within the scope of this report to estimate the capital cost of a "grass roots" fiberboard mill.

It is recommended that this alternative be given consideration in a future study, since it represents a more labor intensive, less capital intensive step than the pulp mill/fiberboard mill complex presented in the scope of this study.

REFERENCES

1. Wet Process Fiberboard Plant, case study prepared for the FAO Portfolio of Small Scale Wood-Based Panel Plants, by Defibrator Fiberboard AB, Stockholm, Sweden for February 1975 Delhi World Consultation on Wood-Based Panels.

2. Defibrator AB March 1977 proposal for a 100 T/D Wet Fiberboard plant in Thailand.

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FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

FIBERBOARD PLANT
IN
PULP MILL COMPLEX
CAPITAL COST ESTIMATE

ITEM	ESTIMATED COST (U.S. DOLLARS)
Equipment	$ 9,100,000
CIF and Local Handling	1,100,000
Equipment Installation, Piping & Wiring	1,800,000
Structures	1,200,000
Incremental Steam and Power Generation	1,100,000
Engineering	700,000
Contingencies	1,300,000
TOTAL PLANT CAPITAL	$16,300,000
Startup Costs	$ 600,000
Working Capital	1,100,000
Interest During Construction	1,000,000
TOTAL PLANT INVESTMENT	$19,000,000

MAIN

U. S. DEPARTMENT OF AGRICULTURE
FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

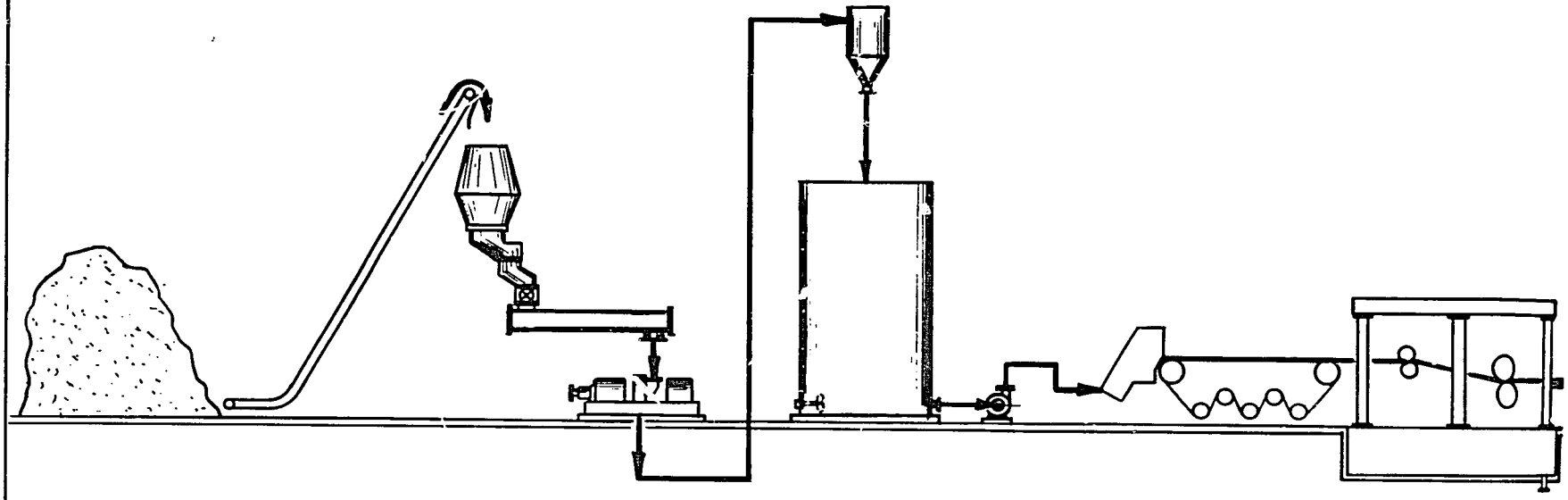
ECONOMIC INFORMATION

Wet process fiberboard plants can produce a wide variety of products for the building industry and furniture industry. By special finishing treatments such as painting, laminating, printing, embossing, etc., the use range of the products may be expanded for both local and export markets.

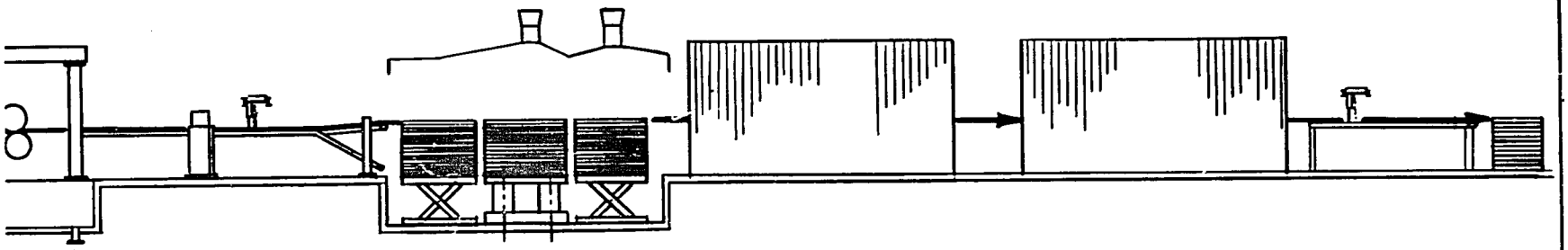
In accordance with the instructions in the specifications, the capital cost of the fiberboard mill has been estimated to be in the order of $19 million. Information is provided on the data sheet for the fiberboard operation to enable the calculation of production cost of hardboard. Requirements in raw material, labor and services are shown.

It is assumed that the greater part of production would be marketed locally. The selling price will vary depending on market demand in a particular area, and in respect to competitive products available. Therefore, for purposes of this report, the information required for potential planners to calculate the production cost is given. It is suggested that when a specific site is selected, a marketing study be initiated to determine the demand for specific fiberboard products and the expected market price. Once this is established, the plant capital costs and operating costs may be calculated with the information shown in this report, and a return on investment may be calculated in the manner shown in the pulp mill section of this report.

As mentioned previously, it is suggested to potential planners and investors to study a fiberboard operation as an earlier step in development of a project than incorporation with a pulp mill. As an auxiliary operation to a sawmill, the cost of wood from residues may improve the economics of the operation.


CHIP BIN
CYCLONE
STEAMING TUBE
PRESS SECTION
PULPWOOD CHIPS
REFINER
STOCK TANK
PUMP
WET FORMING MACHINE

PULPING



TIPPLE

CTION

WET SAW

DRY SAW

CALIPER

PRESS DRYER

HEAT TREATMENT

HUMIDIFYING

DRY SHEET FINISHING

FIBERBOARD MACHINE

REPORT	
NO. DATE DESCRIPTION	
DESIGNED BY	
PROJECT ENGINEER R. J. ALBERT	
PROJECT MGR. R. N. ZABE	
IN CHARGE C. D. BASSETT	
MAIN CHAS. T. MAIN INTERNATIONAL, INC.	
U.S. DEPT. OF AGRICULTURE FOREST PRODUCTS LABORATORY TROPICAL HARDWOOD UTILIZATION	
DRAWING DESCRIPTION PROCESS FLOW DIAGRAM 100 T/D FIBER BOARD MILL	
SCALE	
3254 - 1	0002

PULP MARKETING

CURRENT HARDWOOD PULP MARKET

In 1976 world pulp production was greater than in 1975. Asia, Oceania and Latin America reached new records, while North America and Europe were not up to 1975 levels. In mid 1977 pulp prices weakened, North American and Scandinavian (NORSCAN) market pulp inventories increased to close to 3 million tons at the end of 1976. In 1977 NORSCAN market pulp inventories were approximately at the same level.[1]

Bleached hardwood Kraft inventories followed the same trend. At the end of 1976, NORSCAN bleached hardwood Kraft inventories stood at approximately 400 thousand metric tons. In mid-1977 the inventory was about the same. Table 1 shows the inventories of bleached hardwood Kraft by countries for this period. NORSCAN pulp shipments of all chemical pulps were about 15 million metric tons in 1974. The forecast for 1977 is approximately 13 million metric tons with an actual record of approximately 12.6 and 12.3 metric tons for 1976 and 1975 respectively.[2] With a total NORSCAN capacity of 16-½ million metric tons per year and reduced operating rates in the low 80's, it does not appear that the inventory has been worked off to any degree over the past year. As mentioned before, current inventories of total chemical pulps are in the order of 3 million metric tons. This has resulted in pulp market weakness around the world and in a lowering of market pulp prices for most grades.

Compounding the problem for bleached hardwood Kraft is the situation in Brazil. In 1976 there was a capacity for approximately 1.1 million metric tons of short fiber, by 1980 this

capacity is projected to increase to approximately 2.5 million tons. Brazil had previously set a goal of exporting 2 million tons of pulp a year by 1980. Recent concern about a continuing pulp surplus through 1980 for short fiber pulp has caused the planning agencies to revise their assumptions downward, and they now project pulp exports in the order of 1.1 million metric tons in 1980 although the available capacity would be greater.[3]

Table 2 shows production, consumption, capacity and operating rate data projected for the Brazilian pulp industry through 1980.[3] Note the one million metric ton capacity increase in hardwood pulp between 1977 and 1980, as well as projected export tonnage. Table 3 shows the market pulp potential from 1977 through 1980 for the new mills projected to be completed during that period.[3] This table indicates capacities of the various mills and tonnages for export. You will note that these four mills project an export tonnage of 900,000 metric tons in 1980.

In addition to the projects described in Table 3, other mills are being considered in Brazil for startup in the early 1980's. Table 4 lists these mills and gives their current status. Africa also has several pulp mills planned for startups through the late 1970's and early 1980's. Although the status of these mills is sometimes difficult to perceive, a 45,000 metric ton per year expansion in Morrocco has been completed and mills in Gabon and Nigeria are being discussed for start ups sometime after 1980.[2]

In the overall picture, the supply-demand situation for bleached hardwood Kraft pulp indicates that a pulp surplus will continue through 1980. In order for the situation to improve, the NORSCAN pulp inventory overhang must be eliminated. In addition the market must be able to accumulate the large tonnage which apparently will be coming from Brazil during this period.

Pulp pricing is weak at the present time, and looks as if it will remain unstable for the near future. To make things worse, allegedly discounting is taking place, resulting in lower than list prices at the present weakness in the market.

PROJECTED HARDWOOD PULP MARKET

A study was completed in late 1977 by an Industry Working Party at the request of the FAO advisory committee of pulp and paper, to present a projection of consumption and demand for paper, paperboard and white chemical pulp in 1980 and 1990; and to compare it with the same figures for the base year 1972-1974. Phase III of this study deals with white chemical pulps. For purposes of this study, we have extracted the information from that report for bleached hardwood Kraft pulps. This information is presented in Table 5. This information indicates that North America and Latin America will be net exporters of bleached hardwood Kraft pulp in 1980 and 1990, and that Western Europe and Japan and other Eastern Hemisphere nations will be net importers of that pulp. In particular, Japan will import 320,000 metric tons per year by 1980, and 1,200,000 metric tons per year by 1990. In the subcategory other Eastern Hemisphere, the Far East will be balanced in imports and exports in 1980, and will export 410,000 in 1990.

Consumption of bleached hardwood Kraft pulp in the Far East will increase from the 1972-1974 level of 170,000 tons per year to 290,000 tons per year in 1990.

As a market forecast for the Far East area, we are using the FAO figures in this study. The consumption, according to these figures, increased from 170,000 tons per year in the 1972-1974 area to 290,000 tons per year of bleached hardwood Kraft pulp in 1990.

For Japan we are also using the FAO study figures. Consumption is shown to increase from 2,900,000 tons per year in

the 1972-1974 area to 5,700,000 tons per year in 1990.

Since information on the centrally planned nations was difficult to obtain, the FAO study assumed that the effect on interregional trade with these nations would be negligible.

PHILIPPINE MARKET

To give an indication of the amount of pulp which may be in demand in the Philippines, Table 6 is enclosed in this study. This table shows the projected domestic demand for paper and paperboard through 1985. The study shows an average annual growth of 4.4 percent in the period 1976 to 1980, and an average annual growth of 3.8 percent from 1980 to 1985. In the areas where hardwood Kraft may be utilized, writing and printing paper has an average growth of approximately 1.8 percent per year in the period 1976 to 1985. Newsprint has an average growth in the order of 3.3 percent for that period. Tissue has an average growth of approximately 2.4 percent for the same period. Although paperboard and industrial paper are not normally thought of as being produced from bleached hardwood Kraft, it may be possible in the local market use that pulp as part of the furnish for these grades.

MARKETS FOR PROJECTED MILL

The specification for the new pulp mill in this study calls for capacity of 500 tons per day of bleached market grade pulp. Because of the size it is assumed that this pulp cannot be sold substantially within the producing country, but must be sold on the world market. As such, we have shown it to be a mill to produce an 88 brightness pulp to be competitive with market pulps produced by other countries, although pulp quality and pricing may be different for usages within some ASEAN nations. For purposes of this study, it is assumed that the mill presented here, located in Southeast Asia and will supply a portion of the consumption increase in the Far East, and will supply a portion of the imports for Japan. It is assumed that the requirements of Western Europe

will be satisfied by exports from North America and Latin America.

PULP PRICES

It is very difficult at this time to establish a true market price for bleached hardwood Kraft. Current U.S. FOB list prices are $250 to $270 per short ton.[3] It has been reported that major Scandanavian pulp producers are listing hardwood Kraft pulp at approximately $325 per metric ton and allegedly the transaction price level is in the order of $310 to $315.[4] The same report indicates that eucalyptus pulp from a Portuguese mill is also listed in Europe at a $325 contract price, but is allegedly being sold at $310 to $315. In early 1976, CIF prices for bleached hardwood Kraft pulp in Europe were reported to be in the order of $415 per ton.[5]

In this report pulp prices will be presented in a sensitivity analysis to allow a reflection of the effect of pulp price change on the feasibility of the project. It is believed that the current pulp prices are somewhat near the expected low and could range up to the 1975-76 level over an extended period. Selling expenses are dependent upon the method used by the mill and would include agents commission and perhaps discounts. In this analysis, no allowance has been made for either. Customs and duties have not been included in the sales price of the pulp. These, of course, vary from country to country. In this preliminary study, no attempt has been made to analyze their effect on sales price.

In the feasibility analysis of the bleached hardwood Kraft mill in the Philippines, the assumption is made that there will be a market for the pulp which will enable the mill to run on an annual production schedule of 350 days per year.

In view of the current surplus of bleached hardwood Kraft pulp, which will exist probably into the early 1980's, there does not appear to be a guarantee that there will always be such a market. However, a mill being contemplated at this time will probably have a startup date after 1985, at which time the projected imports to Japan indicate better prospects for hardwood pulp sales.

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5. FAO Working Paper 16, 7/76, A Geographical Comparison of Sulphate and Newsprint Manufacture

U.S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE
FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOODS UTILIZATION

TABLE I

NORSCAN INVENTORIES

(Thousand Metric Tons)

COUNTRY	END 7/77	END 12/76
Canada	58	41
USA	88	80
Finland	94	119
Sweden	158	162
TOTAL	398	402

Source: Pulp & Paper International

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Table 2

Brazilian Pulp Industry, 1966-1980E
(million metric tons)

Year	Production			Imports	Exports	Apparent Consumption	Capacity			Operating Rate
	Long Fiber	Short Fiber	Total				Long Fiber	Short Fiber	Total	
1966	214	238	452	14	17	449				
1970	278	386	664	46	30	680				
1973	330	642	972	122	189	905				
1974	379	750	1,129	174	133	1,171				
1975	359	830	1,189	80	152	1,118				
1976	451	803	1,254	57	138	1,173	569	1,170	1,739	72.1%
1977E	480	900	1,380	55	200	1,235	601	1,407	2,008	68.7
1978E			1,690	50	420	1,320	706	1,781	2,487	68.0
1980E			2,635	50	1,100	1,585	1,065	2,476	3,541	74.4
Compound Growth										
1966-1976			10.7%			10.1%				
1976-1980E			20.4			7.8	17.0%	20.6%	19.5%	

Goldman Sachs Research
T. Clephane, 11/15/77

Table 3

Brazilian Market Pulp Potential Through 1980
(thousand metric tons)

	Rated Capacity	1977	1978	1979	1980
Production					
Cenibra(a)	260	60	210	255	255
Aracruz(a)	400	-	130	265	365
Riocell(a)	220	190	210	210	210
Jari	260	-	-	130	225
Total	1,140	250	550	860	1,055
For export					
Cenibra(a)	260	40	170	210	210
Aracruz(a)	400	-	80	230	320
Riocell(a)	220	90	125	125	150
Jari	260	-	-	130	225
Total	1,140	130	375	695	905

(a) Abecel Forecast.

Goldman Sachs Research
T. Clephane 11/15/77

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BEST AVAILABLE DOCUMENT

Table 4
Major Expansion Projects in Brazil

Project	Capacity (metric tons)	Product	Startup	Cost millions Mill	Cost millions Project	Comments
Cenibra	260 000	Eucalyptus Pulp	2nd Qtr	$240	$350	In Operation. Ownership-51% Vale do Rio Doce, 49% Japanese Consortium.
Aracruz	400 000	Eucalyptus Pulp	Mid-1978	340	550	Under construction. Ownership- British American Tobacco 21%, Billerud 7%, IP dropped 20% share.
Jari	260 000	Gmelina Pulp	Early 1979	225	325	Plant built on barges in Japan to arrive in April 1978. Rest of year for installation & testing. Ownership-Daniel Ludwig, no partners. Amazon location.
Braskraft	200 000	Kraft Linerboard	1st Half 1980		275	Construction stopped because of potential pollution. Ownership-33% Continental Group, 33% Plantar-local group. Sell 33% in domestic market, rest export.
Klabin	140,000	Kraft Paper or linerboard	Mid-1979	230		Pulp line will start in mid-1978 - machine follows in mid-1979.
Riocell	220 000	Eucalyptus Pulp	1979	NA		Operating now as unbleached mill, taken over by Brazilian group from Borregaard. Will add bleaching system in 1979.
Guatapara	175 000	Eucalyptus Pulp	Late 1980		200	Ordering equipment. Ownership-Brazilian interests. Mostly for internal market.
Certrisa	250 000	Market Pulp 50% pine, 50% Eucalyptus	Late 1981		NA	Project status is uncertain. No financing approval yet Ownership-Crown Zellerbach 33%.
Paranaprint	150,000	Newsprint	1981		NA	Project status is uncertain. Macmillan Bloedel participation is doubtful, Plantar group also involved.
Bracell	270	Eucalyptus Pulp				Project canceled - approval for machinery import from Angola not given.
Embrasca	260 000	Pine pulp	1984			Project is active; planting plantations now. Start construction in 1980. Ownership-Macmillan Bloedel Brascan
Mobosa	330 000	Pine pulp & eucalyptus	1983			Project is doubtful. MoDo may not proceed as partner.
Itapera	300 000	Eucalyptus Pulp	1982			Project is very doubtful - location in Mato Grosso considered too remote.

-Goldman Sachs Research, T Clephane 11 15 77-

TABLE 5

FAO SURVEY
WORLD OUTLOOK FOR WHITE CHEMICAL PULP
BLEACHED HARDWOOD KRAFT PULP

Area	Million Metric tons 1972-74	1980	1990	% of all White Pulp 72/74	80	90
World Consumption	12.4		25.1	28	33	37
North America						
Production	6.2	7.4	9.4			
Consumption	5.5	6.7	8.6	27	30	33
Exports	0.67	0.69	0.79			
% Self-sufficient	112	110	109			
Western Europe						
Production	2.3	3.2	4.6			
Consumption	2.9	4.0	6.4	24	28	35
Imports	0.67	0.82	1.8			
% Self-sufficient	77	80	72			
Japan						
Production	2.9	3.5	4.5			
Consumption	2.9	3.8	5.7	68	73	73
Imports (Exports)	(0.02)	0.32	1.2			
% Self-sufficient	101	92	79			
Latin America						
Production	0.5	1.4	3.1			
Consumption	0.5	0.9	2.1	40	53	65
Imports (Exports)	0	(0.5)	(1.0)			
% Self-sufficient	100	150	150			
Other Eastern Hemisphere						
Production	0.37	0.50	1.96			
Consumption	0.36	0.52	0.80	33	36	31
Imports (Exports)	(0.01)	0.02	(1.16)			
% Self-sufficient	103	95	245			
Middle East & North Africa						
Production	0.05	0.08	0.25			
Consumption	0.01	0.03	0.05			
Imports (Exports)	(0.04)	(0.05)	(0.20)			
% Self-sufficient	500	261	463			
Africa South of the Sahara						
Production	0.04	0.063	0.57			
Consumption	0.04	0.070	0.15			
Imports (Exports)	0	.007	(0.42)			
% Self-sufficient	100	90	380			
Far East						
Production	0.17	0.23	0.70			
Consumption	0.17	0.23	0.29			
Imports (Exports)	0	0	(0.41)			
% Self-sufficient	100	100	243			

Source: FAO World Pulp and Paper Corporation Outlook
Phase III - 1977

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TABLE 6

Projected Philippine Domestic Demand for Paper and Paperboard

(Thousand Metric Tons)

Year	Industrial Paper	Writing and Printing Paper	Newsprint	Tissue	Paperboard	Total Projected Demestic Demand
1976	186.2	67.6	79.1	16.0	83.4	432.3
1977	199.4	67.9	82.1	16.3	85.6	451.3
1978	212.9	70.2	85.1	16.7	88.8	473.7
1979	226.4	71.4	88.1	17.1	90.0	493.0
1980	239.8	72.7	91.0	17.6	92.2	513.3
1981	253.5	74.0	94.0	18.0	95.4	534.9
1982	267.0	75.2	97.0	18.4	96.6	554.2
1983	280.6	76.5	100.0	18.8	99.8	575.7
1984	294.1	77.9	103.0	19.3	102.0	596.3
1985	307.6	79.1	106.0	19.7	104.2	616.6
Average Annual Growth (%)						
1976-1980	6.6	1.9	3.5	2.4	2.6	4.4
1980-1985	5.1	1.7	3.1	2.3	2.5	3.8

INFORMATION OBTAINED FROM PULPAPEL OF PHILIPPINES

Sources of Data : a) NEDA National Income Accounts for data on the index of the volume of manufacturing production and personal consumption expenditures.

b) The Technical Staff, Board & National Education for enrollment data.

December 20, 1977

MAIN

U.S. DEPARTMENT OF AGRICULTURE
FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
TROPICAL HARDWOOD UTILIZATION

500 T/D KRAFT PULP MILL

FINANCIAL

The financial section for the 500 T/D kraft pulp mill consists of the following components:

1. Total Investment Cost - The estimate of plant capital costs, working capital requirements, startup costs, mill related infrastructure costs, and the cost of capital during construction.

2. Manufacturing Costs - The direct manufacturing costs included are: wood costs for pulp (from H.C. Mason, Inc.), cooking and bleaching chemicals cost, materials cost, fuel costs (both fuel oil and fuel wood), and labor costs.

3. Financial Analysis - Translation of the cost data along with various revenue assumptions into a form which will be meaningful to potential investors. Based on a five year engineering and construction period, four years from startup to full production, twenty year plant life, fifteen year loan repayment at 12% interest, 40% equity investment, the following were calculated: profit and loss; cash flow; debt service ratio; and discounted cash flow return on equity.

COST ESTIMATES - INVESTMENT

1. The Total Investment is composed of the following:

Total Plant Capital
Working Capital
Startup Costs
Mill Related Infrastructure
Interest During Construction

The Total Investment Cost is summarized in Appendix I, Table 1
The Construction Costs by year are detailed in Appendix I, Table 2
The Total Investment Requirements by year are shown in Appendix I, Table 3

A. Total Plant Capital. -

The capital cost includes the cost of all process equipment and systems as described in Section I, subsections 1 through 19 and is based on current cost estimates of equipment manufacturers; actual costs of recent projects completed by MAIN, with adjustment made for size variations; and cost estimates from recent FAO studies.

All costs have been escalated to the third quarter, 1977.

The spare parts estimate is based on recommendations of equipment manufacturers, actual inventory levels of existing mills operating in developing countries, adjusted for size variations, and MAIN's experience.

It has been assumed that this project would be funded through international financing and therefore, no import duties have been included in the estimate of costs.

Summary figures for the total plant capital estimate are shown in Appendix I, Tables 4 through 7.

B. Working Capital. -

The working capital requirement has been based on the amount deemed reasonable to fill the processing "pipelines" and continue operations until receivables have been collected. The basis for determining working capital is: receivables (at cost), two months; pulp in warehouse (at cost), one month; chemicals and fuel in storage, one month; wood in yard, one-half month.

Working capital calculations are shown in Appendix II, Table 8.

C. Startup Costs. -

Included in startup costs are: the training in the U.S of Southeast Asian nationals who will become supervisors in the pulp mill; the U.S. pulp mill operations personnel who will be at the mill during the startup period; the equipment manufacturer's representatives who will supervise the initial startup and operation of specialized equipment; and miscellaneous items required for startup only.

Startup Costs are shown in Appendix II, Table 9.

D. Mill Related Infrastructure. -

The mill related infrastructure costs included consist of minimum roads, water supply, waste facilities, a communication system, electricity distribtion, bulk materials systems; and the on site services and amenities for the senior staff such as housing, recreational facilities, a chapel and medical facilities.

Mill Related Infrastructure Costs are estimated in Appendix II, Table 10.

E. Interest During Construction. -

Financing costs for the mill during the construction period were calculated at a 12% cost of money and based on 60% debt financing over the last three eyars of the five year construction period.

The schedule of financing is shown in Appendix IV, Table 19A.

COST ESTIMATES - MANUFACTURING

2. The Manufacturing Cost is estimated as follows:

Wood Costs - Wood for Pulp
Cooking and Bleaching Chemicals Costs
Materials Cost
Fuel Cost - Fuel Oil/ Fuel Wood
Labor Costs

The Manufacturing Costs are summarized in Appendix III, Table 11. The Manufacturing Costs by year are shown in Appendix III, Table 12.
The Labor Costs are detailed in Appendix III, Table 13.

A. Wood Costs - Wood for Pulp

The cost per cubic meter of wood for pulp is estimated in Section 3 of this report. The equivalent cost per bleached ton is calculated from this figure after an allowance is made for bark and fines removal and is based on an average oven dry specific gravity of 0.48 and a bleached pulp yield of 40%.

B. Cooking and Bleaching Chemicals Costs

These costs are based on the totals derived from the prices from mill records and supplier information as applied to the usage rates shown for each chemical.

C. Materials cost is based on information received from discussions with pulp mill personnel and from judgement by MAIN.

D. Fuel Costs. -

Lime kiln fuel oil requirements are based on actual calculations and have been compared with existing operations. The price of $.12 per liter of fuel oil has been obtained from existing operating mill records and government sources for the locations selected for this study.

Wood fuel boiler total heat requirements have been determined for this mill and this information is summarized on the heat balance which has been included with this report.

Fuel oil is assumed to provide 20% of the heat requirement for the wood fuel boiler.

Fuel wood cost per cubic meter is estimated in Section 3 of this report. The equivalent cost is based on an oven dry specific gravity of 0.48 and a heat value of 8,500 BTU per lb.

Waste wood (bark and fines from pulp wood) costs have been included in the unit cost of pulp wood.

E. Labor costs are estimated from the manpower requirements and costs shown on the table included in this report. Information for this table has been derived form the following sources: actual mill operation, FAO reports for similar pulp mills and MAIN experience.

It is anticipated that the full production rate will be achieved in the fifth year of operation. Capacity utilization during this period is estimated to be as follows: 50%, 75%, 85%, 95% and 100%.

3. Financial Analysis

MAIN's financial analysis examines the feasibility of this pulp mill project to potential investors on the basis of the following financial indicators:

A. Discounted Cash Flow Return on Equity. The discounted before tax cash flow rate of return on equity investment was used in this financial analysis to give potential equity investors a useful tool to evaluate this project. The rate of return was determined which balanced discounted equity investment with the discounted stream of net cash flows from the first year of operation through the expected life span of the investment (which in this analysis is assumed to be the 20th year of operation).

B. Debt Service Ratio

This measure was selected in this financial analysis to show the project's ability to meet debt obligations on both the interest and repayment of the debt principal. This ratio is calculated by dividing the estimated gross profit of the enterprize in any year by the payments of both interest and loan repayment.

Profit and loss and cash flow projections were calculated based on several different revenue, and financing assumptions to demonstrate the financial situation under selected alternative conditions. It was seen that at present market prices, this would not be a profitable venture. In order to permit a meaningful financial analysis prices were taken to cover a range which would result in a positive return on equity. This range went from $375/Ton; to a level which would yield a reasonable return, $475/Ton; with a base case taken at $425/Ton.

This information has been tabulated in summary form and is shown in Appendix IV.

Table 14 - $375/Ton	Profit & Loss - Cash Flow - Debt Service Coverage Net Return on Equity
Table 15 - $425/Ton	Profit & Loss - Cash Flow - Debt Service Coverage Net Return on Equity
Table 16 - $475/Ton	Profit & Loss - Cash Flow - Debt Service Coverage Net Return on Equity

Variations in revenues, manufacturing cost, and capital cost demonstrate the sensitivity of the return on equity to these assumptions. Sensitivity tests have been made and are presented in two forms in Appendix IV.

Table 17 Sensitivity Tests - Tabulated
Table 18 Sensitivity Analysis - Graph

Analysis of this data shows that the return on equity is marginal at $375/Ton; 8%± at $425/Ton; and 12%± at $475/Ton. The return on equity is most sensitive to changes in revenues.

Assumptions for Financial Analysis:

A. Sales Price for Pulp is assumed to be $425 per metric air dry ton, FOB pulp mill. Results were also calculated using $375 and $475/ADT as the sales price. (For exported pulp the applicable cost, insurance and freight must be added.)

B. Manufacturing Cost is based on the following production rates as a percentage of design production: year 6, 50%; year 7, 75%; year 8, 85%; year 9, 95%, and year 10, 100%.

C. Depreciation is based on straight line over a 20 year plant life. Depreciable assets are taken as total investment less spare parts, working capital, infrastructure and site related costs. For depreciable assets of $219,260,000, the annual depreciation is $10,963,000.

D. Financing is based on equity capital of $106,000,000 and debt capital of $160,000,000 (60%). The loan is repaid over a period of fifteen years with payments starting in the second operating year. The constant finance charge (principal and interest) or annuity is calculated based on 12% interest.

The financing schedule, Appendix IV, Table 19A, and the amortization schedule, Appendix IV, Table 20 give the details for this financing.

For purposes of comparison, a financial analysis is presented based on 40% debt capital. The financial schedule, Appendix IV, Table 19B; the amortization schedule, Appendix IV, Table 21; and the profit and loss - cash flow - debt service coverage - net return on equity table, Appendix IV, Table 22; have been included.

Appendix I - Investment Costs

		Page
Table 1	- Total Investments Cost Summary	9.11
Table 2	- Construction Costs By Year	9.12
Table 3	- Total Investment Requirements By Year	9.13
Table 4	- Direct Cost Of Plant Capital	9.14
Table 5	- Direct Cost Of Plant Capital By Year	9.15
Table 6	- Plant Capital Indirect Proportions By Year	9.16
Table 7	- Plant Capital Indirect Costs By Year	9.17

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN

MAIN

TABLE 1
TOTAL INVESTMENT COST - SUMMARY

Plant Capital	
Capital Cost	$159,500,000
Spare Parts	7,000,000
Construction Overhead	6,500,000
Engineering	13,000,000
Contingencies	18,000,000
Total Plant Capital	$204,000,000
Working Capital	11,400,000
Startup Costs	4,000,000
Mill Infrastructure	11,000,000
Interest During Construction	35,600,000
Total Investment	$266,000,000

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN
TABLE 2
CONSTRUCTION COSTS BY YEAR (US $1000)

MAIN

CONSTRUCTION COSTS BY YEAR (US $1000)

Item/Year	1	2	3	4	5	Total
Plant Capital	34,000	40,000	55,000	45,000	30,000	204,000
Working Capital	------	------	------	------	11,400	11,400
Infrastructure	2,200	2,200	3,300	2,200	1,100	11,000
Startup		400	625	625	2,350	4,000
Total	36,200	42,600	58,925	47,825	44,850	230,400
Grand Total	230,400					

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN
TABLE 3
TOTAL INVESTMENT REQUIREMENTS BY YEAR

MAIN

TOTAL INVESTMENT NEEDED EACH YEAR OF CONSTRUCTION (US $1000)

	1	2	3	4	5	Total
Capital Investment	36,200	42,600	58,900	47,800	44,900	230,400
+ Interest	------	------	4,800	11,700	19,100	35,600
Total Investment	36,200	42,600	63,700	59,500	64,000	266,000

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN
TABLE 4
DIRECT COST OF PLANT CAPITAL

MAIN

Description	Estimated Cost
Chip Harvesting & Processing (H.C. Mason)	$ 8,600,000
Chip Handling	2,800,000
Subtotal - Chip Systems	$ 11,400,000
Pulping	13,770,000
Evaporator & Concentrator	8,000,000
Recovery Boiler	15,200,000
Precipator	5,900,000
Liquor Preparation	9,250,000
Bleach Plant	10,900,000
Bleach Chemical Preparation	3,900,000
Bleach Pulp Storage System	1,600,000
Pulp Processing & Finishing	13,900,000
Warehouse	1,800,000
Water Treatment	2,400,000
Water Distribution	1,500,000
Steam Distribution	1,400,000
Primary Power Distribution	2,700,000
Effluent Treatment	5,600,000
Turbine Generator	7,300,000
Wood Fueled Boiler	14,680,000
Power Plant Auxiliaries	3,500,000
Diesel Motor Generator	1,100,000
Yard & Site Development	18,400,000
Shops & Stores	3,200,000
Personnel Services	1,900,000
Security	200,000
Subtotal - Pulp Mill	$148,100,000
Total Plant Capital	$159,500,000

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN
TABLE 5
DIRECT COST OF PLANT CAPITAL BY YEAR (US $1000)

MAIN

	YEAR 1	2	3	4	5	Total
*Owner Furnished	19,555	27,406	14,278	12,684	8,447	82,370
*Contractor Furnished	8,090	8,090	29,090	24,140	7,720	77,130
Totals	27,645	35,496	43,368	36,824	16,167	159,500

*Items Included:

Equipment

Piping

Electrical

Process Control

Structures

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN
TABLE 6
PLANT CAPITAL - INDIRECT COSTS - PROPORTIONS BY YEAR (US $1000)

MAIN

Construction Years	Construction Overhead 6,500	Contingencies 18,000	Spare Parts 7,000	Engineering 13,000
1	.5	.1	0	.1
2	0	.1	0	.2
3	.5	.2	0	.4
4	0	.3	0	.2
5	0	.3	1.0	.1
Total	1.0	1.0	1.0	1.0

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN

MAIN

TABLE 7

PLANT CAPITAL - INDIRECT COSTS BY YEAR (US $1000)

	Year 1	Year 2	Year 3	Year 4	Year 5
Direct Costs	27,645	35,496	43,368	36,824	16,167
Construction Overhead	3,250	0	3,250	0	0
Contingencies	1,800	1,800	3,600	5,400	5,400
Spare Parts	-------	------	------	------	7,000
Engineering	1,300	2,600	5,200	2,600	1,300
Totals	33,995	39,896	55,418	44,824	29,867

Grand Total 204,000

Appendix II - Investment Costs		Page
Table 8	- Working Capital	9.19
Table 9	- Startup Costs	9.20
Table 10	- Mill Related Infrastructure	9.21

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN

TABLE 8
WORKING CAPITAL

MAIN

Working Capital

Receivables (At Cost)	- 2 months	@ $213,80/Ton Pulp	= $6,200,000
Pulp in Warehouse	- 1 month	@ $213.80/Ton Pulp	= $3,100,000
Chemicals In Storage (Including Fuel Oil)	- 1 month	@ $80,00/Ton Pulp	= $1,300,000
Pulp Wood	- ½ month	@ $92.90/Ton Pulp	= $ 680,000
Fuel Wood	- ½ month	@ $25.62/Ton Pulp	= $ 120,000
TOTAL WORKING CAPITAL			$11,400,000

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN

TABLE 9
STARTUP COSTS

MAIN

Total Startup Costs

A) 30 men to U.S. for training as Supervisors

3 years @ $15,000/Man/Yr	=	$1,350,000
6 months @ $10,000/Man/Yr @ Mill	=	150,000

B) 15 men from U.S. for Startup

1 year @ $40,000/Man/Yr	=	600,000

C) 30 men from U.S. Equipment Mfr.

6 months @ $80,000/Man/Yr	=	1,200,000
TOTAL STARTUP LABOR		$3,300,000
MISCELLANEOUS STARTUP COSTS		700,000
TOTAL STARTUP COSTS		$4,000,000

Startup Costs By Year

	1	2	3	4	5
A)		285,000	450,000	450,000	225,000 150,000
B)					600,000
C)					1,200,000
Misc.		175,000	175,000	175,000	175,000
TOTAL COST/YR	$0	$400,000	$625,000	$625,000	$2,350,000

FOREST PRODUCTS LABORATORY PRELIMINARY INDUSTRIAL SURVEY MIXED TROPICAL HARDWOOD 500 T/D KRAFT PULP MILL	SHEET 1 OF 1 JOB NO. 3254-1 DATE: Dec. 20, 1977
DATA FOR BASIS OF DESIGN TABLE 10 MILL RELATED INFRASTRUCTURE	MAIN

Mill Related Infrastructure

Raw Water Transmission	$ 4,600,000
Roads - 15 Miles	500,000
Pier & Warehouse	850,000
Bulk Chemical Facilities	750,000
Electrical Distribution	1,600,000
Services and Amenities - Senior Staff (Housing, Hospital, Chapel, Recreation Facilities)	2,400,000
Other Infrastructure Items	300,000
TOTAL MILL RELATED INFRASTRUCTURE	$11,000,000

Infrastructure Disbursement Schedule

During Construction Years

Year 1	20%	$ 2,200,000
Year 2	20%	2,200,000
Year 3	30%	3,300,000
Year 4	20%	2,200,000
Year 5	10%	1,100,000
	100%	$11,000,000

Appendix III - Manufacturing Costs		Page
Table 11	- Manufacturing Costs Summary	9.23 to 9.24
Table 12	- Manufacturing Costs By Year	9.25
Table 13	- Labor Costs	9.26

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN

TABLE 11.

MANUFACTURING COSTS - SUMMARY

MAIN

	Delivered Cost ₱/Ton Chem	Quantity Used # Chem/ Ton Pulp	Manufacturing Cost ₱/Ton Pulp	Manufacturing Cost US$/AD MTon Pulp
Wood Cost				
Wood for Pulp $17.30/M^3 = $37.16/Ton Chips to Digester @ 40% Yield				92.90
Cooking Chemicals				
Salt Cake	850	150	63.50	
Lime	75	175	6.60	
Caustic	2250	20	22.50	
Pitch Dispersants	600	62	18.50	
Defoamer	1210	32	19.30	
Sub Total			130.40	17.40
Bleaching Chemicals				
Chlorine	2465	88	108.50	
Caustic	2250	105	118.00	
Sodium Chlorate	3250	40	65.00	
Sodium Chloride	645	21	6.80	
Sulfuric Acid	630	33	10.40	
Sulfur Dioxide	795	4	2.00	
Sub Total			310.70	41.40
Misc. Chemicals				
Water & Cond. Treatment	2250	15	16.90	2.30
Papermaking Chemicals				
Pitch Dispersants Biocide				2.00
Materials				
Maintenance	$1,690,000/Yr			9.70

NOTE: 7.5 ₱ = $1 US.

DATA FOR BASIS OF DESIGN

TABLE 11

MANUFACTURING COSTS - SUMMARY

MAIN

		Manufacturing Costs US $/AD MTon Pulp
Fuel Costs		
Lime Kiln: Fuel Oil Cost	35,620 l/Day @ 0.90 ₱/l; 350 D/Yr; 175,000 T/Yr	8.60
Wood Fuel Boiler: Fuel Oil Cost	36,835 l/Day @ 0.90 ₱/l; 350 D/Yr; 175,000 T/Yr	8.90
Wood Fuel	$13.55/M^3 = $25.62/ODT X 276.6 ODT/D @ 500 T/D Pulp	14.20
Labor Cost		
Expatriate	$706,000/Yr	4.10
Local	$2,153,000/Yr	12.30
TOTAL OPERATING COSTS		213.80

Pulp Wood Cost/M^3 = $17.30 (From H.C. Mason, Section 3, Page 34)

$17.30	M^3	FT^3	2200 LB	1.0 OD	1.0 Equiv Wood	Yield	= $92.90/M Ton Bleached Pulp
M^3	35.314 FT^3	62.4 (.48)LB	M Ton	1.1 AD	0.88 Pulp Chips	0.40	

Fuel Wood Cost/M^3 = $13.55 (From H.C. Mason, Section 3, Page 34)

$13.55	M^3	FT^3	2000 LB	= $25.62/Ton Wood Chips
M^3	35.314 FT^3	62.4 (.48)LB	Ton	

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN

TABLE 12

MANUFACTURING COSTS BY YEAR

MAIN

Item	Year 1	2	3	4	5 - 20
% Capacity	50%	75%	85%	95%	100%
Wood Cost	8,128,750	12,193,125	13,818,875	15,444,625	16,257,500
Cooking Chemicals	1,522,500	2,283,750	2,588,250	2,892,750	3,045,000
Bleaching Chemicals	3,622,500	5,433,750	6,158,250	6,882,750	7,245,000
Misc. Chemicals	201,250	301,875	342,125	382,375	402,500
Papermaking Chemicals	175,000	262,500	297,500	332,500	350,000
Materials Maint.	848,750	1,273,125	1,442,875	1,612,625	1,697,500
Fuel Costs	2,773,750	4,160,625	4,715,375	5,270,125	5,547,500
Labor Costs	1,435,000	2,152,500	2,439,500	2,726,500	2,870,000
Total	18,707,500	28,061,250	31,802,750	35,544,250	37,415,000

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN
TABLE 13
LABOR COSTS

MAIN

	Class	Number Employed	Annual Labor Cost Per Employee US$/Year	Total Labor Cost This Classification US$/Year	Equiv. Cost Per Ton Pulp (175,000 T/Yr)
General Manager	1	1	96,000	96.000	
Production Manager	2	1	60,000	60,000	
Department Managers	3	8	50,000	150,000	4.06
Office Managers	4	25	16,000	400,000	
Engineers & Senior Technical	5	30	8,000	240,000	
Department Supervisors - Day	6	30	6,000	180,000	
Supervisors - Shift	7	25	4,000	100,000	12.30
Mill Workers - Day	8	255	3,500	895,000	
Mill Workers - Shift	9	195	2,400	468,000	
Office Clerical & Security	10	135	2,000	270,000	
TOTALS		705		$2,859,000	$16.36

Appendix IV - Financial Analysis | Page

Table 14	- $375/Ton Financial Analysis	9.28
Table 15	- $425/Ton Financial Analysis	9.29
Table 16	- $475/Ton Financial Analysis	9.30
Table 17	- Sensitivity Tests - Return On Equity - Tabulated	9.31
Table 18	- Sensitivity Tests - Return On Equity - Graph	9.32
Table 19	- Financing Schedules	9.33
Table 20	- Amortization Schedule	9.34
Table 21	- Amortization Schedule - Alternate Financing	9.35
Table 22	- $375/Ton Financial Analysis - Alternate Financing	9.36

TABLE 16 - $475/ton PROFIT & LOSS - CASH FLOW - DEBT SERVICE COV

Forest Products Laboratory
Preliminary Industrial Survey
Mixed Tropical Hardwood
500 T/D Kraft Pulp Mill

	1	2	3	4	5	6	7	8	9	10	11	12
Profit & Loss												
Sales Revenue						41563	62344	70656	78969	83125	83125	83125
Manuf. Cost (-)						18708	28061	31803	35544	37415	37415	37415
Gross Profit						22855	34283	38853	43425	45710	45710	45710
Depreciation (-)						10963	10963	10963	10963	10963	10963	10963
Interest (-)						19200	19200	18685	18108	17462	16738	15928
Profit Before Tax						(7308)	4120	9205	14354	17285	18009	18819
Cash Flow: Sources												
Equity	36200	42500	24100	1460	1900							
Debt	-	-	40000	58000	62000							
Cash (Operations)	-	-	-	-	-	22855	34283	38853	43425	45710	45710	45710
Total Cash Available	36200	42500	64100	59460	63900	22855	34283	38853	43425	45710	45710	45710
Disposition of Funds												
Plant Capital	34000	39900	55375	44875	29580							
Infrastructure	2200	2200	3300	2200	1100							
Working Capital					11400							
Test & Start-up	-	400	625	625	2350							
Interest	-	-	4800	11760	19200	19200	19200	18685	18108	17462	16738	15928
Repayment of Debt	-	-	-	-	-	-	4292	4807	5384	6030	6754	7564
Total Dispersed	36200	42500	64110	59460	63900	19200	23492	23492	23492	23492	23492	23492
Net Cash Flow	-	-	-	-	-	3655	10791	15361	19933	22218	22218	22218
Debt Service Coverage Ratio						1.19	1.46	1.65	1.85	1.95	1.95	1.95
Net Return on Equity (%)	-	-	-	-	-	-	3.9	8.7	13.5	16.3	17.0	17.8

ERVICE COVERAGE - NET RETURN ON EQUITY (in thousands)

60% Debt 40% Equity
20 yr. Straight line depreciation - $10963/year
15 year financing @ 12%
Equity - $106,160

L	12	13	14	15	16	17	18	19	20	21	22	23	24	25
125	83125	83125	83125	83125	83125	83125	83125	83125	83125	83125	83125	83125	83125	83125
415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415
710	45710	45710	45710	45710	45710	45710	45710	45710	45710	45710	45710	45710	45710	45710
963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963
738	15928	15020	14004	12865	11590	10162	8562	5770	4764	2522	-	-	-	-
009	18819	19727	20743	21882	23157	24585	26185	27977	29983	32225	34747	34747	34747	34747
710	45710	45710	45710	45710	45710	45610	45710	45710	45710	45710	45710	45710	45710	45710
710	45710	45710	45710	45710	45710	45710	45710	45710	45710	45710	45710	45710	45710	45710
738	15928	15020	14004	12865	11590	10162	8562	6770	4764	2522	-	-	-	-
754	7564	8472	9488	10627	11902	13330	14930	16722	18728	20970	-	-	-	-
492	23492	23492	23492	23492	23492	23492	23492	23492	23492	23492	-	-	-	-
218	22218	22218	22218	22218	22218	22218	22218	22218	22218	22218	45710	45710	45710	45710
.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	-	-	-	-
.0	17.8	18.6	20.0	20.6	21.8	23.2	24.6	26.4	28.4	30.3	32.7	32.7	32.7	32.7

9.28 a

6 19
5 10
1 9

TABLE 15 - $425/ton PROFIT & LOSS - CASH FLOW - DEBT SERVICE COVER

Forest Products Laboratory
Preliminary Industrial Survey
Mixed Tropical Hardwood
500 T/D Kraft Pulp Mill

	1	2	3	4	5	6	7	8	9	10	11	12
Profit & Loss												
Sales Revenue						37188	55781	63219	70656	74375	74375	74375
Manuf. Cost (-)						18708	28061	31803	35544	47315	37415	37415
Gross Profit						18480	27720	41416	35112	3 960	36960	36960
Depreciation (-)						10963	10963	10963	10963	10963	10963	10963
Interest (-)						19200	19200	18685	18109	17462	16738	15928
Profit Before Tax						(11683)	(2443)	1768	6041	8535	9259	10069
Cash Flow: Sources												
Equity	36200	42500	24100	1460	1900							
Debt	-	-	40000	58000	62000							
Cash (Operations)	-	-	-	-	-	18480	27720	31416	35112	36960	36960	36960
Total Cash Available	36200	42500	64100	59460	63900	18480	27720	31416	35112	36960	36960	36960
Disposition of Funds												
Plant Capital	34000	39900	55375	44875	29850							
Infrastructure	2200	2200	3300	2200	1100							
Working Capital					11400							
Test & Start-up		400	625	625	2350							
Interest	-	-	4800	11760	19200	19200	19200	18685	18108	17462	16738	15928
Repayment of Debt	-	-	-	-	-	-	4292	4807	5384	6030	6754	7564
Total Dispersed	36200	42500	64100	59460	63900	19200	23492	23492	23492	23492	23492	23492
Net Cash Flow	-	-	-	-	-	(720)	4228	7924	11620	13468	13468	13468
Debt Service Coverage Ratio						.79	1.18	1.34	1.49	1.57	1.57	1.57
Net Return on Equity (%)	-	-	-	-	-	-	-	1.7	5.7	8.0	8.7	9.5

RVICE COVERAGE - NET RETURN ON EQUITY (in thousands)

60% Debt 40% Equity
20 yr. Straight line depreciation - $10963/year
15 year financing @ 12%
Equity - $106,160

	12	13	14	15	16	17	18	19	20	21	22	23	24	25
75	74375	74375	74375	74375	74375	74375	74375	74375	74375	74375	74375	74375	74375	74375
15	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415
60	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960
63	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963
38	15928	15020	14004	12865	11590	10162	8562	5770	4764	2522	-	-	-	-
59	10069	10977	11993	13132	14407	15835	17435	19227	21233	23475	25997	25997	25997	25997
60	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960
60	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960	36960
38	15928	15020	14004	12865	11590	10162	8562	6770	4764	2522	-	-	-	-
54	7564	8472	9488	10627	11902	13330	14930	16722	18728	20970	-	-	-	-
92	23492	23492	23492	23492	23492	23492	23492	23492	23492	23492	-	-	-	-
68	13468	13468	13468	13468	13468	13468	13468	13468	13468	13468	36960	36960	36960	36960
7	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	-	-	-	-
7	9.5	10.3	11.2	12.4	13.6	14.9	16.4	18.1	20.0	22.1	24.5	24.5	24.5	24.5

TABLE 14 - $375/ton PROFIT & LOSS - CASH FLOW - DEBT SERVICE COVE

Forest Products Laboratory
Preliminary Industrial Survey
Mixed Tropical Hardwood
500 T/D Kraft Pulp Mill

	1	2	3	4	5	6	7	8	9	10	11	12
Profit & Loss												
Sales Revenue	-	-	-	-	-	32813	49219	55781	62344	65625	65625	65625
Manuf. Cost (-)						18708	28061	31803	35544	37415	37415	37415
Gross Profit						14105	21158	23978	26800	28210	28210	28210
Depreciation (-)						10963	10963	10963	10963	10963	10963	10963
Interest (-)						19200	19200	18683	18108	17462	16738	15928
Profit Before Tax						(16058)	(9005)	(5068)	(2271	(215)	509	1319
Cash Flow: Sources												
Equity	36200	42500	24100	1460	1900							
Debt	-	-	40000	58000	62000							
Cash (Operations)	-	-	-	-	-	14105	21158	23978	26800	28210	28210	28210
Total Cash Available	36200	42500	64100	59460	63900	14105	21158	23978	26800	28210	28210	28210
Disposition of Funds												
Plant Capital	34000	39900	55375	44875	29850	-	-	-	-	-	-	-
Infrastructure	2200	2200	3300	2200	1100	-	-	-	-	-	-	-
Working Capital	-	-	-	-	11400	-	-	-	-	-	-	-
Test & Start-up	-	400	625	625	2350	-	-	-	-	-	-	-
Interest	-	-	4800	11760	19200	19200	19200	18685	18108	17462	16738	15928
Repayment of Debt	-	-	-	-	-	-	4292	4807	5384	6030	6754	7564
Total Dispersed	36200	42500	64100	59460	63900	19200	23492	23492	23492	23492	23492	23492
Net Cash Flow	-	-	-	-	-	(5095)	(2339)	496	3308	4718	4718	4818
Debt Service Coverage Ratio	-	-	-	-	-	-	-	-	-	1.2	1.2	1.2
Net Return on Equity (%)	-	-	-	-	-	-	-	-	-	-	0.5	1.2

ERVICE COVERAGE - NET RETURN ON EQUITY (in thousands)

60% Debt 40% Equity
20 yr. Straight line depreciation - $10963/year
15 year financing @ 12%
Equity - $106,160

	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	65625	65625	65625	65625	65625	65625	65625	65625	65625	65625	65625	65625	65625	65625
15	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415
10	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210
63	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963	10963
38	15928	15020	14004	12865	11590	10102	8562	6770	4764	2522	-	-	-	-
09	1319	2227	3243	4382	5657	7145	8685	10477	12483	14725	17247	17247	17247	17247
10	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210
10	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	15928	15020	14004	12865	11590	10162	8562	6770	4764	2522	-	-	-	-
54	7564	8472	9488	10627	11902	13330	14930	16722	18728	20970	-	-	-	-
92	23492	23492	23492	23492	23492	23492	23492	23492	23492	23492	-	-	-	-
18	4818	4718	4718	4718	4718	4718	4718	4718	4718	4718	28210	28210	28210	28210
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	-	-	-	-	-
5	1.2	2.1	3.1	4.1	5.3	6.7	8.2	9.9	11.8	13.9	16.3	16.3	16.3	16.3

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN
TABLE 17
SENSITIVITY TESTS ON RETURN ON EQUITY
FOR SELECTED CONDITIONS

MAIN

Price At Mill ($)	Debt-/Equity Ratio	Manufacturing Cost-Plant Capital Cost (% Variation In Input)		Internal Rate/Of Return On Equity %
425/Ton (BASE CASE)	60/40	100	100	7.7
475/Ton	60/40	100	100	11.7
375/Ton	60/40	100	100	2.4
425/Ton	60/40	100	120	3.8
425/Ton	60/40	100	80	12.1
425/Ton	60/40	120	100	3.3
425/Ton	60/40	80	100	11.2
375/Ton	40/60	100	100	5.1

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

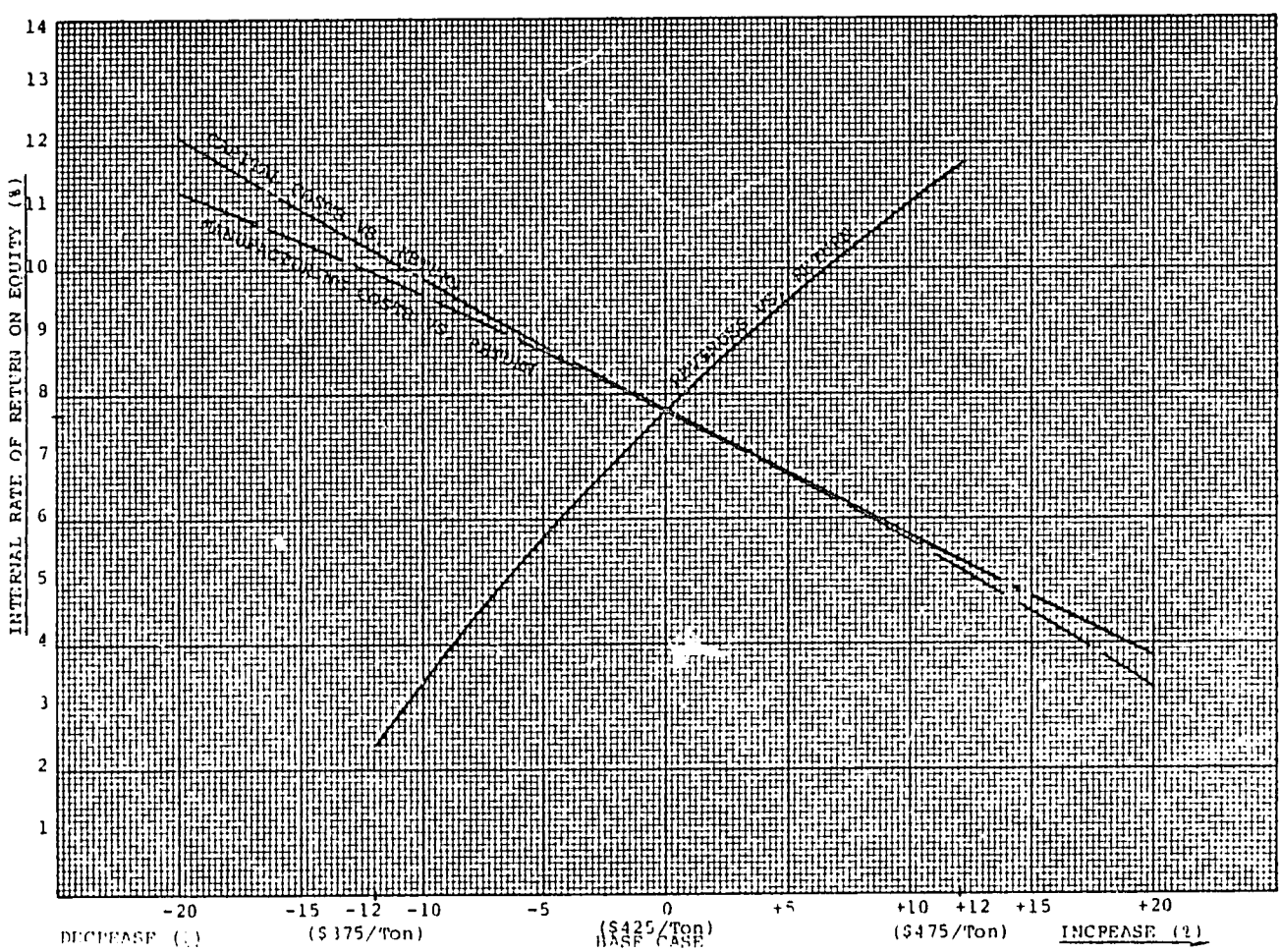
SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN
TABLE 18

SENSITIVITY TESTS - INTERNAL RATE OF RETURN ON EQUITY

MAIN

SENSITIVITY TESTS ON INTERNAL RATE OF RETURN ON EQUITY



DATA FOR BASIS OF DESIGN
TABLE 19
FINANCING SCHEDULES

MAIN

Table 19A - Financing Schedules

60% Debt - 40% Equity Financing (In Thousands)

Year	1	2	3	4	5	Total
Equity	36,200	42,500	24,100	1,460	1,900	106,160
Debt	------	------	40,000	58,000	62,000	160,000
IDC.			4,800	11,760	19,200	35,760
Total Investment						266,160

Table 19B - Financing Schedules

40% Debt - 60% Equity Financing (In Thousands)

Year	1	2	3	4	5	Total
Equity	31,000	31,000	31,000	31,000	31,000	155,000
Debt	5,200	11,500	28,300	16,700	13,700	75,400
IDC.	624	2,004	5,400	7,404	9,048	24,480
Total Investment						254,880

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN

TABLE 20

AMORTIZATION SCHEDULE

MAIN

FINANCING: 15 YEARS

Financing $266 MM with $160 MM Debt and $100 MM Equity (In Thousands)

Year	Loan Balance	12% Annuity	Interest	Amortization
1	160,000	23,492	19,200	
2	160,000	23,492	19,200	4,292
3	155,708	23,492	18,685	4,807
4	150,901	23,492	18,108	5,384
5	145,517	23,492	17,462	6,030
6	139,487	23,492	16,738	6,754
7	132,733	23,492	15,928	7,564
8	125,169	23,492	15,020	8,472
9	116,697	23,492	14,004	9,488
10	107,209	23,492	12,865	10,627
11	96,582	23,492	11,590	11,902
12	84,680	23,492	10,182	13,330
13	71,350	23,492	8,562	14,930
14	56,420	23,492	6,770	16,722
15	39,698	23,492	4,764	18,728
16	20,970	23,492	2,522	20,970

FOREST PRODUCTS LABORATORY
PRELIMINARY INDUSTRIAL SURVEY
MIXED TROPICAL HARDWOOD
500 T/D KRAFT PULP MILL

SHEET 1 OF 1
JOB NO. 3254-1
DATE: Dec. 20, 1977

DATA FOR BASIS OF DESIGN

MAIN

TABLE 21

AMORTIZATION SCHEDULE - ALTERNATE FINANCING

FINANCING: 15 YEARS

Financing $225 MM with $100 MM Debt and $155 MM Equity (In Thousands)

Year	Loan Balance	12% Annuity	Interest	Amortization
1	100,000	14,682	12,000	2,682
2	97,318	14,682	11,687	3,004
3	94,314	14,682	11,318	3,364
4	90,950	14,682	10,914	3,768
5	87,182	14,682	10,462	4,220
6	82,962	14,682	9,955	4,727
7	78,235	14,682	9,388	5,294
8	72,941	14,682	8,753	5,929
9	67,012	14,682	8,041	6,641
10	60,371	14,682	7,245	7,437
11	52,934	14,682	6,352	8,330
12	44,604	14,682	5,352	9,330
13	35,274	14,682	4,233	10,449
14	24,825	14,682	2,979	11,703
15	13,122	14,682	1,575	13,107

TABLE 22 - $375/ton PROFIT & LOSS - CASH FLOW - DEBT SERVICE COVER

Forest Products Laboratory
Preliminary Industrial Survey
Mixed Tropical Hardwood
500 T/D Kraft Pulp Mill

	1	2	3	4	5	6	7	8	9	10	11	12
Profit & Loss												
Sales Revenue						32813	49219	55781	62344	65625	65625	65625
Manuf. Cost (-)						18708	28061	31803	35544	37415	37415	37415
Gross Profit						14105	21158	23978	26800	28210	28210	28210
Depreciation (-)						10399	10399	10399	10399	10399	10399	10399
Interest (-)						12000	12000	11678	11318	10914	10467	9955
Profit Before Tax						(8294)	(1241)	1901	5083	6897	7349	7856
Cash Flow: Sources												
Equity	31000	31000	31000	31000	31000							
Debt	5824	13504	33700	24104	22748							
Cash (Operations)	-	-	-	-	-	14105	21158	23978	26800	28210	28210	28210
Total Cash Available	36824	44504	64700	55104	53748	14105	21158	23978	26800	28210	28210	28210
Disposition of Funds												
Plant Capital, Infrastructure, Working Capital, Test & Start-up	36200	42500	59300	47700	44700							
Interest	624	2004	5400	7404	9048	12000	12000	11678	11318	10914	10462	9955
Repayment of Debt	-	-	-	-	-	-	2682	3004	3364	3768	4220	4727
Total Dispersed	36824	44504	64700	55104	53748	12000	14682	14682	14682	14682	14682	14682
Net Cash Flow	-	-	-	-	-	2105	6476	9296	12118	13528	13528	13528
Debt Service Coverage Ratio						1.18	1.44	1.63	1.83	1.92	1.92	1.92
Net Return on Equity (%)	-	-	-	-	-	-	-	1.2	3.3	4.4	4.7	5.0

ERVICE COVERAGE - NET RETURN ON EQUITY (in thousands)

40% Debt 60% Equity
20 yr. Straight line depreciation - $10399/year
15 year financing @ 12%
Total Cost - $254,080 Equity - $155,000

.	12	13	14	15	16	17	18	19	20	21	22	23	24	25
625	65625	65625	65625	65625	65625	65625	65625	65625	65625	65625	65625	65625	65625	65625
415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415	37415
210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210
399	10399	10399	10399	10399	10399	10399	10399	10399	10399	10399	10399	10399	10399	10399
467	9955	9308	8753	8041	7245	6352	5352	4233	2979	1575	-	-	-	-
349	7856	8503	9058	9770	10566	11459	12459	13578	14832	16236	17811	17811	17811	17811
210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210
210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210	28210
462	9955	9388	8753	8041	7245	6352	5352	4233	2979	1575	-	-	-	-
220	4727	5294	5929	6641	7437	8330	9331	10449	11703	13107	-	-	-	-
682	14682	14682	14682	14682	14682	14682	14682	14682	14682	14682	-	-	-	-
528	13528	13528	13528	13528	13528	13528	13528	13528	13528	13528	28210	28210	28210	28210
92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92				
7	5.0	5.5	5.8	6.3	6.8	7.4	8.0	8.8	9.6	10.5	11.5	11.5	11.5	11.5

PROJECT FEASIBILITY - PLANNING - ENGINEERING - DESIGN
PROCUREMENT - EXPEDITING - QUALITY ASSURANCE

MAIN

CONSTRUCTION MANAGEMENT - START UP - TESTING - OPERATION
MAPPING - MATHEMATICAL MODELS - COMPUTER SERVICES
MANAGEMENT - ENVIRONMENTAL STUDIES - ECONOMICS

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