"NEW GENERATION HARDWOOD PROCESSING"

A PROPOSAL BY

THE FOREST PRODUCTION COUNCIL OF WESTERN AUSTRALIA

FOR

A PUBLIC INTEREST PROJECT

UNDER SECTION 39 OF

THE INDUSTRIAL RESEARCH AND DEVELOPMENT INCENTIVES ACT, 1976

NOVEMBER 1985

INDEX

1. **PROPOSERS ORGANISATION NAME:**

Forest Production Council - Western Australia.

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TELEPHONE NO:

(09) 386 8811

2. **PROJECT SUPERVISOR:**

Dr F H McKinnell

STATUS:

Divisional Manager - Services, Department of Conservation and Land Management.

TELEPHONE:

(09) 367 6333

QUALIFICATIONS:

Ph.D. (A.N.U.), BSc. (For.), Dip. For. (Canb.)

3. GENERAL DESCRIPTION OF PROJECT:

3.1 Introduction

All states of Australia face the crisis of diminishing supplies of mature hardwood. This threatens to escalate Australia's massive import bill which already approaches $900 million annually. Predictions of global timber shortages, particularly in hardwoods, make the utilization of regrowth forests an urgent necessity.

In Western Australia it has become necessary to reduce the quantity of logs cut from mature native forests over the next 50-70 years in accordance with the Government's policy of achieving sustained yields. The timber industry is as a result, facing significant reductions in its traditional log resource (Attachment 1). Similar action is required in most states of Australia.

Because of their overstocked condition, many regrowth, or new generation forests are growing more slowly than they could. To redress this situation there is a need to establish techniques for commercial processing of small logs. This will achieve two objectives:-

- maintain timber supplies in the short term
- increase the log resource to provide for expanding industries in the future.

The potential benefits of an immediate increase in hardwood sawlog yield of some 200,000m^3/year, producing in excess of $25 million value to the green sawn stage, is recognised by the WA Government and by members of the Forest Production Council.

To realise these benefits the Government has invested $460,000 during the past two years with a total exceeding $1,000,000, on the capital development of the Wood Utilization Research Centre at Harvey. Research staff salaries have exceeded $200,000 annually and other operating expenses $160,000 annually.

The Government has a responsibility to obtain the best possible return from all state forest resources and to maintain them in perpetuity. Until conversion technologies have been established and proven, it would not be acting in the best public interest if it guaranteed the new generation of trees to private companies.

There is considerable risk involved for private industry to develop the technologies required without guaranteed access to the log resource. Therefore, significant private investment in research and development cannot be expected.

Timber from all eucalypts, but especially from young trees, tends to degrade during seasoning. Consequently most eucalypt markets are for structural timber where seasoning defects are less critical than for higher value furniture and cabinet woods. Markets for high quality timber for furniture are rapidly increasing as sources of traditional cabinet woods, such as the world's rain forests, diminish. Keith R Bootle, in the introduction to a recent Forestry Commission of NSW book entitled, "Wood in Australia", had this to say.

> "The rapid decline in availability of the rainforest species, of fine appearance and medium density, is a worldwide phenomenon. In Australia it must surely lead to greater consideration for decorative use of many of our eucalypt hardwoods, of rich colour and beautiful figure, but which present production difficulties because of their high density. However, this does not seem to be an insurmountable problem, as is already indicated by the increasing use of jarrah as a furniture wood".

Because this changing resource coincides with a reducing market demand for structural hardwoods, the emphasis of this project is to develop processes for the maximum recovery of cabinet quality timber. The potential markets for fine red coloured cabinet timbers, such as jarrah, is particularly encouraging. Increasing local demand is recorded in the attached Technical Paper No. 11.

The Department of Conservation and Land Management has a Wood Utilization Research Centre which is in the heart of the new generation jarrah forests at Harvey, 140 km south of Perth. Equipment includes a sawmill designed for handling small logs, several types of kiln seasoning facilities, dressing equipment and a mechanical proof grading machine (Attachment 3). As such it is well suited for applying the modern industrial research necessary to conduct this project.

Salaried research staff are presently drawn from several sections of the Department and from a number of professional and technical disciplines. A list of the research staff and their qualifications are appended (Attachment 2).

To respond to consumer demand, a concerted research effort by foresters, sawmillers, wood processors, timber merchants and wood product manufacturers has the best prospects of success. Nowhere in Australia is the research environment better structured for this integrated forest-based industry approach, than in Western Australia.

3.2 Project Outline

The project research techniques will be conducted largely on Eucalyptus marginata (jarrah). However, testing of other eucalypts, both native to Western Australia and to other states will be included to determine the variations in techniques necessary to embrace the majority of commercial species across the nation. For this purpose, species native to other Australian states will be drawn from 8,000 hectares of plantings spread over a range of forest sites throughout the south west of Western Australia. These trees range up to 30 years old.

The following species, which are of major economic importance in eastern Australia, and have similar density figures to jarrah, will be included:

E. camaldulensis	River red gum
E. globulus	Tasmanian blue gum
E. grandis	Flooded or rose gum
E. maculata	Spotted gum
E. microcorys	Tallowwood
E. pilularis	Blackbutt
E. resinifera	Red Mahogany
E. saligna	Sydney blue gum
E. sieberi	Silvertop Ash

The basic seasoning schedules developed for jarrah could be applied to these. Some slight modifications may be required and although not all of these species would be suitable for furniture timber, the amount of degrade due to seasoning would be considerably reduced.

The trees which need to be removed from the forest are a new generation, not only smaller than can be economically utilized by conventional sawmills, but also with differing physical properties, which affect the further processing and marketing of timber converted from them.

This project envisages the industrial research and development of new techniques for the economic processing of small sized eucalypt sawlogs and subsequent seasoning, to produce high grade cabinet woods, joinery and other timber products.

Specialist industry groups acting under the guidance of a Wood Research Panel of senior industry representatives, will advise on specific stages of the project. This Panel has statewide representatives of forestry, sawmilling, timber manufacturing, the Technology Development Authority, and a representative of the Australian Timber Research Institute.

The program will need to run for four years as follows:

1st Year	-	Construction phase
2nd & 3rd Years	-	Two complete seasonal cycles of operational research
4th Year	-	Application of results to commercial operations.

To develop techniques for the commercial processing of the new generation jarrah, four stages of research are proposed.

Stage 1 - Sawmill conversion

Stage 2 - Seasoning

Stage 3 - Product development and marketing

Stage 4 - Wood residue utilization

Stage I Sawmill Conversion

To produce furniture timber, the equipment requires scanning facilities to optimize quality output rather than quantity. The initial step proposed is to commission an electronics specialist (eg from the CSIRO or UWA) to evaluate alternative concepts of scanning of logs and partly processed flitches, such as 3D light scanning and defect detection by ultrasonics. This will be followed by contracting the development to private companies.

Because most furniture timber is required in short lengths, the capacity to process short logs provides an important method of improving recovery without prejudicing quality. The basic equipment at the Harvey Wood Utilisation Research Centre has the capacity to handle logs as short as 1.2 metres. This feature is believed to be unique in research sawmills and is certainly not available in commercial mills which mostly have minimum length requirements at least double this figure.

The Department of Conservation and Land Management have already invested over $300,000 in the Harvey sawmill. Its development to meet the project needs will therefore be less expensive than the requirements for specialist staff to conduct the research.

Stage 2 Seasoning

The second stage in processing is designed further to develop existing and to establish new seasoning techniques for commercial application. An expanding furniture manufacturing industry demands very high quality timber, free of the defects caused by poor seasoning techniques (See Technical Paper No 11).

Research over the past 12 months at Harvey, into the application of progressive kiln technology in association with high temperature kiln seasoning has produced very promising results with mature jarrah. The best results were obtained using high humidity in the initial seasoning process, followed by a high temperature treatment.

The intrinsic wood properties of eucalypts are very good. However, at the present time, most eucalypt timber in Australia is used in the rough sawn, unseasoned state for general building construction. Higher value uses such as for furniture and as engineered structures are needed to compensate for a reducing availability. Seasoning is the key to obtaining higher values. The work with mature jarrah needs to be developed for other species and for timber from immature trees.

Jarrah seasoning problems are typical of a broad range of commercial eucalypts throughout Australia with similar densities.

The Progressive Tunnel Kiln

Heated progressive tunnel seasoning is an old concept. In recent years it was successfully tested by the CSIRO in Melbourne for seasoning structural timbers. It has been developed commercially.

Research at Harvey, however, has demonstrated that the addition of heat is largely responsible for surface splitting which, although unimportant in structural grades, is the most serious defect in furniture timber.

The innovation to the progressive tunnel kiln concept needed to improve its performance for appearance timbers, is to operate it below ambient temperatures. In this respect and in some important design features, the proposal differs from the CSIRO work and the original concept of the heated progressive tunnel kiln. This approach offers a very low cost and effective method of seasoning hardwoods from the green state to fibre saturation point (about 27% moisture content).

The High Temperature Kiln

Research into high temperature seasoning of mature jarrah has been in progress for three years commencing with Millars (Aust) Ltd, and now with Bunning Bros Pty Ltd. The program has been an outstanding success with conservative figures of a fourfold reduction in surface splitting and a tenfold reduction in the seasoning cycle time.

The schedules for mature jarrah are being optimized and the development of similar techniques for the new generation hardwoods, is an important function of the Public Interest Project.

As in the sawmill conversion stage, a considerable investment has been made in terms of research facilities. The major funding required for development of the work into regrowth hardwoods is for skilled research workers and for commercial development of the equipment.

Stage 3 Product Development and Marketing

Although an increasing demand for mature jarrah for furniture has been established, and it is expected to continue, the market environment can never be taken for granted. Continuing research is necessary to establish target markets, particularly as the new generation hardwoods are likely to be perceived as new product raw material, with differing colour and physical properties.

It is anticipated, in spite of making significant improvements in the recovery of high value, appearance quality timber, that there will always be a proportion of eucalypt logs which will not produce high quality timber. Consequently, structural and other purpose markets, will also be needed to ensure the optimum utilization.

A program of systematic examination of a range of products in relation to the needs of consumers, is proposed. This is the development of existing technology to convert the products of the first two stages of the project to forms which meet market demands.

The project envisages an efficient plant for upgrading and reprocessing timber for the needs of manufacturers and consumers. The development of edge and face gluing to meet the demands for large section material will be investigated.

Production and marketing of veneers from regrowth logs will be researched in association with local veneer manufacturers. Producing veneer from regrowth logs, with different mechanical and physical properties, creates similar problems to those experienced with solid wood conversion.

Matched solid wood and veneered products from regrowth logs will be investigated with furniture manufacturers.

Because considerable input is expected by private companies for these developments, it is not possible to list the products for fear of breaching the commercial confidences established with those companies. Other products requiring development are expected to emerge as experience is gained with the processing of regrowth timber.

Present market trends point clearly to an increasing demand for jarrah for furniture and fine cabinet construction both in Australia and overseas. The project aims to research the application of new generation jarrah to these end uses.

Indicative values for a cubic metre of furniture grade timber at various stages of processing are as follows:

	$/m^3$
In the log (royalty only)	15
Rough sawn green, at the mill	340
Rough sawn green, Perth	430
Rough sawn seasoned, Perth	760
Furniture grade 1, Perth	1,840

The high price of furniture timber demonstrates the problems faced by industry in obtaining quality material using existisng technology.

Marketing promotion will be carried out by private companies and the costs will be subsidised by the value of timber produced during the research program.

Stage 4 Wood Residue - Utilization

A prototype fluidised bed combustor was successfully tested during 1984-85, to utilize wood wastes for the operation of the high temperature kiln at Harvey.

This prototype plant, developed by Pyrotherm Pty Ltd, has high performance levels in several key areas. These include the ability to combust or gasify green wood residues in a single stage, the ability to operate efficiently on a small scale and a low capital cost. As this plant is now available for additional research, it is proposed to investigate additional uses for wood residues.

This stage need not be conducted concurrently with the other stages but the financial viability of processing young eucalypts could depend on making greater use of the residues resulting from the production of other products.

Two specific research proposals are on the drawing board, one for sawdust/lime curing and the other for the refining of gypsum.

Investigation of additional products of pyrolysis and distillation of wood residues is proposed. The scope of this proposal includes a detailed literature search and a comprehensive market analysis as a preliminary to laboratory and field testing programs.

The significance of residue utilization can be gauged by the following table which shows the estimated volume of wood residues available at sawmills for 1983 in Western Australia.

Sawlogs produced		808,000	m^3
Sawn wood produced (includes overcut)		300,000	m^3
Sold as chips		77,000	m^3
Sold as firewood		47,000	m^3
Other residue sales (nurseries, landscape etc)		10,000	m^3
Residue balance available	- volume	374,000	m^3
	- weight green	400,000	t
	- weight dry	300,000	t

4. ESTIMATED COSTS

FOUR YEAR PROJECT COSTS

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	Total
Construction	1,245,000	-	-	-	1,245,000
Research	435,000	892,000	970,000	1,089,000	3,386,000
TOTAL	1,680,000	892,000	970,000	1,089,000	4,631,000

Details of cost estimates and planning programs are shown in attachment 4.

5. STATE OF THE ART SUMMARY

Integrated research and development of this nature is not being undertaken elsewhere in Australia at the present time. This proposed project emphasises a maximum recovery into furniture quality timber by the application of modern technology supported by a direct commitment by all sectors of the forest based industry. This approach is believed to be unique in Australia and is in direct response to market demand.

Successful performance of this project will be a benefit to forest based industries in all States. It also has significant implications for exporting the products and the processing technologies to overseas countries where eucalyptus trees have been planted to alleviate regional timber shortages.

6. INDUSTRIAL PROPERTY SITUATION

(a) No patents are held by the parties concerned.

Patents likely to arise from the project work are:

* Small diameter, short length log conversion equipment.

* Ultrasonic timber quality evaluation equipment.

* Ultrasonic cant resaw optimizing software.

(b) No other patents are likely to impinge on the project.

(c) A patent search is considered desirable but is not costed in this project.

7. PUBLIC INTEREST CRITERIA

The Project as outlined had the support of a Western Australian Timber Utilization and Marketing Task Force. This Task Force included representatives of all major and some small sawmilling companies, timber merchants, panel products producers, the Forest Products Association, the Housing Industry Association and the Guild of Furniture Manufacturers. In a report submitted to the Western Australian Government in November 1984, the Task Force made a number of recommendations. Four of the recommendations of the Task Force are relevant to this proposal; these are:

(1) Research and development of improved log processing techniques, particularly for hardwood seasoning, be undertaken as a matter of urgency.

(2) As a high priority, the development of markets for the products of regrowth hardwood thinnings be promoted.

(3) The Government encourage expansion of value added timber manufacturing.

(4) A senior level research panel, representing all sections of the forest based industry, be appointed to make recommendations regarding research needs, advise on priorities and ensure prompt dissemination of results.

The Project responds to these recommendations and reflects many other comments expressed by the Task Force.

The public interest benefits expected are:

* to make available from a presently unused resource, additional processed sawn timber; initially for structural purposes and subsequently for high value added products;

  - an immediate increase in hardwood sawlog yield in Western Australia alone of some 200,000m^3/year, producing in excess of $25,000,000 value to the green sawn timber stage;

  - a long term increase in hardwood sawlog yield in Western Australia in excess of 400,000m^3/year, exceeding $100,000,000 in value added products;

* maintenance of direct rural employment in the timber industry of some 1,000 people;

* consolidation and expansion of the furniture manufacturing industry enabling it to make significant export earnings;

* added flow-on benefits to Government of employment, royalties and taxes;

* by improved efficiency of timber usage, reduce the land use conflict between conservation and production forestry;

* possible greater utilisation of minor species;

* reduced need for expenditure on softwood plantations;

* greatly increased water yields from forested catchments.

This project will also give an added stimulus to decentralisation.

8. BENEFITS EXPECTED TO ACCRUE TO PROPOSER

The project will facilitate commercial thinning of the new generation hardwood forests.

In Perth, as for other capitals, unthinned regrowth forests comprise much of the water catchment areas of the city. Water yields from these catchments are less than those covered by the original mature forests. Yields can be significantly increased by thinning, without prejudicing water quality.

The Wood Utilization Research Centre is also being developed as a focal point for training by the WA Timber Industry Training Committee. This role will facilitate technology transfer and the application of research findings.

The principal direct benefit to accrue from the proposed research project is to provide additional resource for increasing production and export earnings.

In addition there are obvious benefits accruing to managers of forests throughout Australia. These include greater royalty returns and the reduced need for expenditure on softwood plantations.

9. INTER-ORGANISATION RELATIONS

The Australian Timber Research Institute (ATRI) was established in 1983. It has established a network of panels and committees serving as valuable communication channels, which are a principal means for updating utilization research workers around Australia. The support of the local ATRI state committee has been obtained regarding the appointment of task oriented technical support groups. These groups will provide the industries' input to specific research working plans, monitor the progress of the work and keep the Wood Research Panel informed on its progress. The Chairman of the local ATRI committee is a member of the Wood Research Panel and is therefore the medium for technical feedback to ATRI in all states.

Detailed proposals were submitted to ATRI for funding in 1983 and 1984 but the priorities for establishing the Institute and for fundamental research were seen to take precedent over these basic and applied research projects. This year, $7,500 has been allocated to Western Australia in the ATRI budget for implementation of sawing technology in W.A.

Firm working relationships exist between the Wood Utilization Research Centre and the Division of Chemical and Wood Technology, CSIRO. A number of the items of research are expected to be contracted out to this body.

Close working arrangements with the W.A. Institute of Technology also exist and use of its facilities and expertise is also envisaged.

10. PREVIOUS AND ONGOING RESEARCH PROGRAMS

The following progress has already been made on research which relates to the project.

* Seasoning mature jarrah. A joint project with Bunning Bros compares conventional techniques at Yarloop mill with the use of the experimental tunnel kilns and the high temperature kilns at Harvey. Significant potential is seen for improving the recovery into higher value grades of jarrah.

  An extended programme covers a greater range of thicknesses, timber from differing geographic areas (e.g. southern jarrah and timber from dieback sites).

* Conversion of the high temperature kiln furnace to wood fuel. This project is being conducted with a W.A. furnace manufacturer, Pyrotherm Pty Ltd. A fluidised bed pilot plant was used as a gasifier to replace the diesel injection equipment in the high temperature kiln for a series of tests using a range of wood fuels produced as residues by the Harvey mill complex.

  High temperature kiln seasoning for pine and hardwood is technically effective but operational costs need to be significantly reduced. Ongoing development aims to reduce the cost to approximately half that when diesel fuel is used, and thereby demonstrate commercial viability for high temperature seasoning of hardwoods.

* Preservative retention in jarrah transition sapwood. A joint project with Bunning Bros tested the variability of preservative retention in sapwood, heartwood and transition wood. Additional work is proposed to establish the commercial significance of the preliminary findings as they relate to the use of regrowth timber.

* Two piece dowelled railway sleepers. This is a joint project with Westrail, the Forest Products Association (W.A.) and Koppers (Aust.) Pty Ltd. Dowelled sections of pinaster pine, radiata pine and jarrah are being tested as replacements for one piece sleepers. The two piece sleepers can be produced from small and knotty trees below present commercial standards and the resultant sleepers show matching strength properties to one piece sleepers of the same species. The trial includes some sleepers seasoned in the high temperature kiln at Harvey. Additional work is planned with regrowth hardwoods.

* Development of Furniture Grade Specifications. The Forest Products Association, the Guild of Furniture Manufacturers and the Department have prepared industry standard specifications for furniture grades of jarrah. These specifications are being tested in the market place.

* End point moisture content determination. A comparison of microwave and conventional oven drying of kiln samples is being conducted in an attempt to speed up the determination of the end point of drying. Results are promising and are particularly important for high temperature seasoning.

Additional details of research and development work by the Wood Utilization Research Centre are given in the attached booklet "Timber From a New Generation Forest".

11. REFEREES

Mr D M Cullity, C.M.G. BSc., Chairman FAO World Committee on Wood Based Panel Products, President Plywood Association of Australia Ltd and member of CSIRO Committee to Review Forests and Forest Products Problems (Pryor Committee 1980), Chairman Joseph William Gottstein Memorial Trust. 1 Somersby Road, Welshpool, 6106. Telephone (09)451.7011.

Dr W E Hillis, DSc. F.T.S., Chief Research Scientist, Wood Science, Division of Chemical and Wood Technology, CSIRO, Highett, Victoria, 3190. Past Co-ordinator, Forest Products Division of the International Union of Forestry Research Organizations. Telephone (03)555.0333.

Mr S L G Morgan B.E. (Hons), M.I.E., MIEE., Managing Director, Westintech Innovation Corporation Ltd, and Associate Commissioner of State Energy Commission, Suite 8, Technology Centre, 2 Brodie-Hall Drive, Bentley WA 6102. Telephone (09)362.4688.

12. FURTHER INFORMATION CONTACTS

Dr G R Siemon, BSc. (For.) Hons. Ph.D., Officer in Charge, Utilization Research, Department of CALM. Telephone (097) 521677.

Mr P N Shedley, BSc. (For.) Dip. For. (Canb.), Utilization and Marketing Officer, Department of CALM. Telephone (09) 3676333.

Dr S R Shea, BSc. Ph.D, Executive Director, Department of Conservation and Land Management and Chairman of the Forest Production Council. Telephone (09)386.8811.

SIGNED: _____ **DATE:** 5/11/85

CHAIRMAN
FOREST PRODUCTION COUNCIL

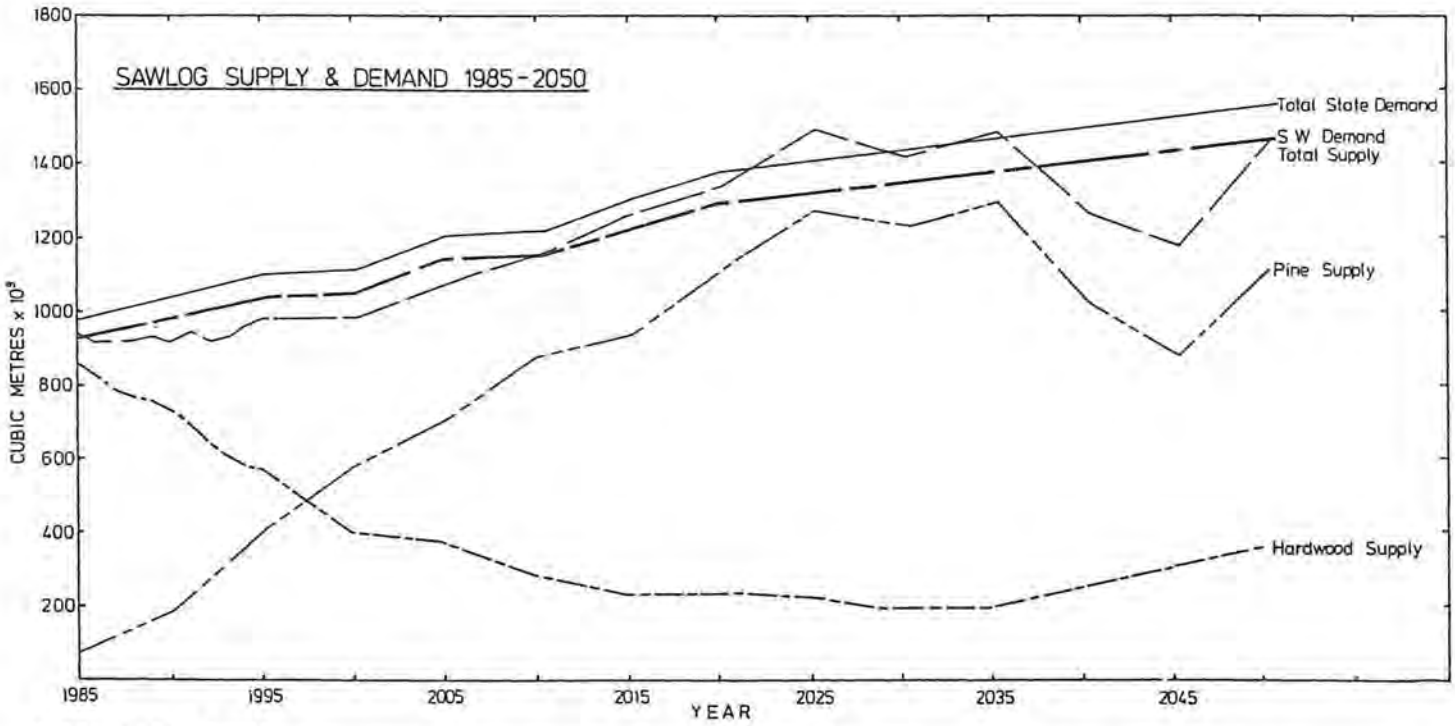
ATTACHMENT 1

Extract From:

"FUTURE TIMBER SUPPLIES FOR WESTERN AUSTRALIA"

By: P J McNamara
Acting Conservator of Forests
February 1984

A Discussion Paper prepared for The Hon. Premier and Minister for Forests by the Forests Department of Western Australia.



NOTES: 1. Pine Supply
1.1 Is based on an annual rate of 3500 ha/year until the year 2008, made up of 3000 ha/year radiata; 500 ha/year pinaster.
1.2 A 10% reduction in yield has been made to allow for losses due to fire, wind, insect, disease.

2. Hardwood Supply
2.1 Assumes no change in hardwood markets, log standards, or processing technology.
2.2 Is based on levels of cut prescribed in GWP 87, but
2.3 Excludes the resource on the Shannon basin, and the proposed northern jarrah reserve.
2.4 Allows for sawlogs from jarrah regeneration after the year 2018.
2.5 Assumes 100 000m^3 sawlogs from private property until 1990, reducing to zero at 1995.

ATTACHMENT 2

MANAGEMENT AND PROJECT STAFF

The operation of the Wood Utilization Research Centre is the responsibility of a departmental panel comprising

Joe Havel - MSc (For) (Qld) Dip. For (Canb.) Dip Ed
Director of Research and Planning

Frank McKinnell - PhD (ANU) BSc (For) Dip For (Canb.)
Divisional Manager - Services

Steve Quain - BSc (For) Dip For (Canb.)
Divisional Manager - Operations

The following team of staff are directly engaged in utilization research.

Phil Shedley, BSc (For) Dip For (Canb.). Co-ordinator, Industry liaison and marketing.

Graeme Siemon, BSc (For) (Hons) PhD. Scientific specialist.

Jack Bradshaw, BSc (For). Silvicultural advisor.

Des Donnelly, Senior Forester. Technical Specialist and Equipment Design.

Gary Brennan, BSc (For), Research project officer.

Greg Beange, AIT Mech Eng. Mechanical engineering.

John Harding, BE (Civil), Structural engineering.

Kevin White, District Forester. Technical construction and research project officer.

Lex Mathews, Forester. - Harvey Manager.

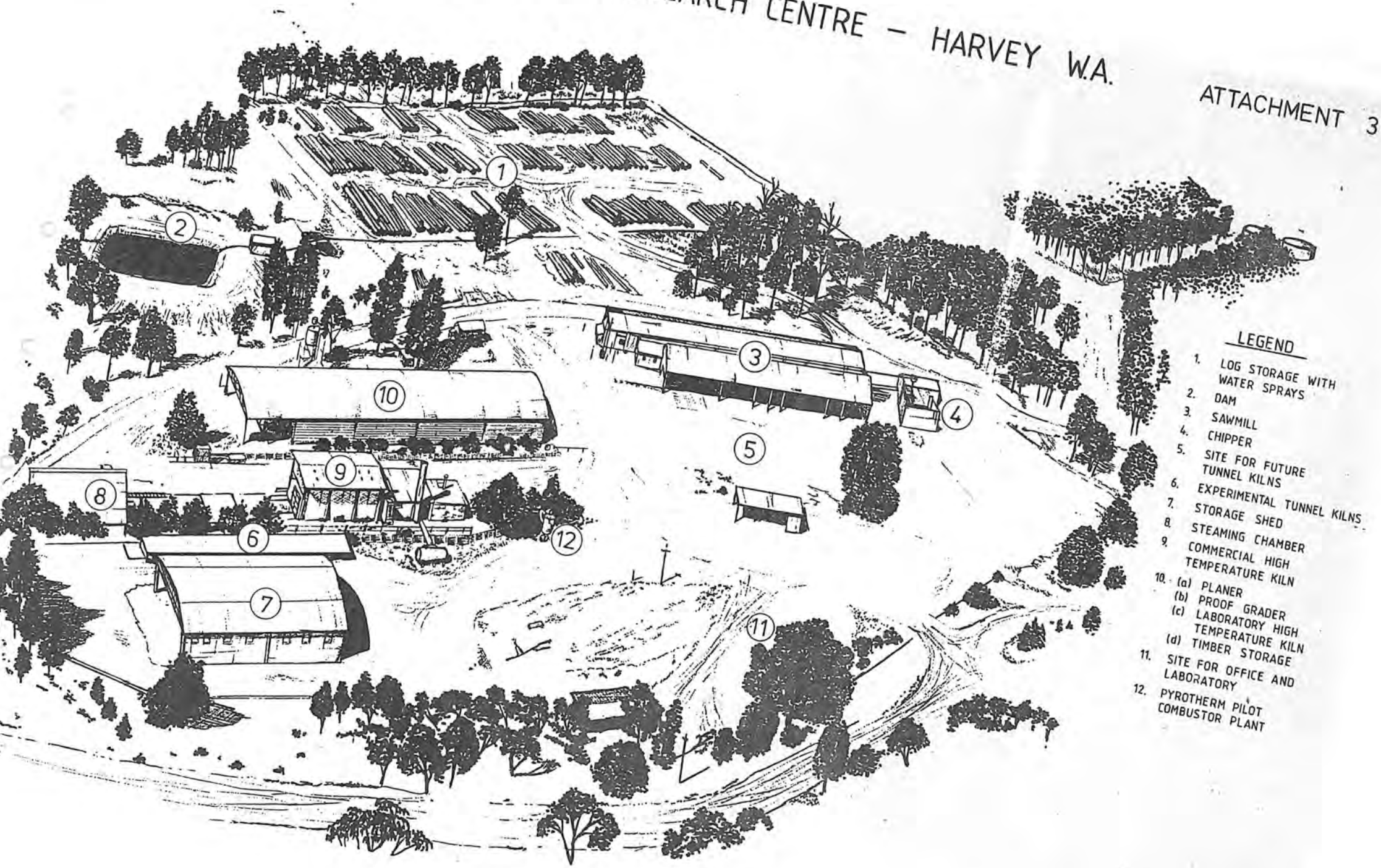
Alan Thomson, BSc (For), Forest Ranger. Clerical and technical assistance.

Don Challis, BA A/Forester. Administration clerical and marketing.

Daryl Peacock, Cert. Civ. Eng. Mechanical and structural drafting.

WOOD UTILIZATION RESEARCH CENTRE – HARVEY W.A.

ATTACHMENT 3



ATTACHMENT 4

PLANNING PROGRAM AND COSTS

PHASE 1 - CONSTRUCTION

The following is a schedule of equipment and facilities to be installed in the first year, together with related construction activities. A diagrammatic representation of this construction planning program is also shown.

1.0	Planning and Contract Management		
	1.1	Equipment and plant design and selection, liaise with suppliers	
	1.2	Call tenders, evaluate, place orders and manage contract.	
			- $ 90,000
2.0	Preliminary Construction Items		
	2.1	Site preparation and earthworks	
	2.2	Upgrade roads	
	2.3	Minor building works and modifications	
			- $ 95,000
3.0	Services		
	3.1	Power - Upgrade site 440V supply New substation and distribution system	- $ 40,000
	3.2	Communications - extend Telecom services and data transmission services	- $ 20,000
	3.3	Water supply, allow for bore, pump and pipework etc	- $ 20,000
	3.4	Sewerage - extend septic tank system to handle extra amenities	- $ 10,000
4.0	Plant		
	Forklift		- $ 40,000
5.0	Stockpile		
	Upgrade existing facilities		- $ 20,000
6.0	De-barker		
	Supply and install		- $100,000

7.0	Edger modifications	- $ 40,000
	Log indexer, improved sawing capacity	
8.0	Bandsaw	
	Replace saw and feed mechanism	- $ 40,000
9.0	Metal detector	- $ 5,000
10.0	Chipper	
	Chipper screen, sawdust separator, bin safety protection and sound attenuation	- $ 45,000
11.0	Flitch Transfer	
	Modifications and additions	- $ 15,000
12.0	Log weighing facility	
	Single axle truck weighbridge	- $ 30,000
13.0	Overhead walkway	
	Safety and inspection of mill	- $ 8,000
14.0	Log scanning	
	3D optical scanners, controller and software	- $135,000
15.0	Timber defect detection	
	Ultrasonic non destructive testing equipment controller and software	- $ 80,000
16.0	Board stripping	
	Humidity controlled stripping room for loading to tunnel kilns	- $ 30,000
17.0	Tunnel kilns	
	For 25, 38 and 50mm material. Buildings, mechanicals, fans, winch electrics and controls, instrumentation controller and software	- $200,000

18.0	Laboratory and test equipment		
	18.1	Kiln load cells	- $ 5,000
	18.2	Data logger, computer and software	- $ 52,000
	18.3	Machining equipment, radio frequency generator and glue press	- $ 90,000
	18.4	Proof grader assurance testing equipment	- $ 35,000
	CONSTRUCTION TOTAL		**$1,245,000**

PHASE 2 - RESEARCH OPERATIONS

The costs involved with this phase cover labour, consumables and contract costs.

The labour requirements in year 1 during the construction phase will be three (3) salaried staff and five (5) wages. As the additional facilities become available for the research operations, the salaried staff needs will rise to five (5) and the wages employees to eight (8).

	Year 1	Year 2	Year 3	Year 4	Total
Labour					
Salaries	135,000	243,000	262,000	284,000	924,000
Wages	150,000	259,000	280,000	302,000	991,000
TOTAL	**285,000**	**502,000**	**542,000**	**586,000**	**1,915,000**
Materials					
Fuel, Power & Water	30,000	70,000	77,000	86,000	263,000
Mobile plant	35,000	65,000	70,000	77,000	247,000
Sundries	5,000	15,000	17,000	20,000	57,000
TOTAL	**70,000**	**150,000**	**164,000**	**183,000**	**567,000**
Contracts					
Logging	60,000	160,000	175,000	190,000	585,000
Strength & durability testing	15,000	22,000	25,000	35,000	97,000
Publications & sundries	5,000	58,000	64,000	95,000	222,000
TOTAL	**80,000**	**240,000**	**264,000**	**320,000**	**904,000**
RESEARCH TOTAL	**435,000**	**892,000**	**970,000**	**1,089,000**	**3,338,000**
CONSTRUCTION TOTAL	**1,245,000**	**-**	**-**	**-**	**1,245,000**
GRAND TOTAL	**1,680,000**	**892,000**	**970,000**	**1,089,000**	**4,631,000**

NOTES

1. The estimated costs are preliminary.

2. The costs apportioned to items 14.0 and 15.0 are 'notional' only and require further investigation.

3. It is expected that the whole of the construction works will be completed in approximately 1 year from commencement with the exception of items 14.0 and 15.0 which require further research of the respective technologies.

4. Labour costs have been calculated as

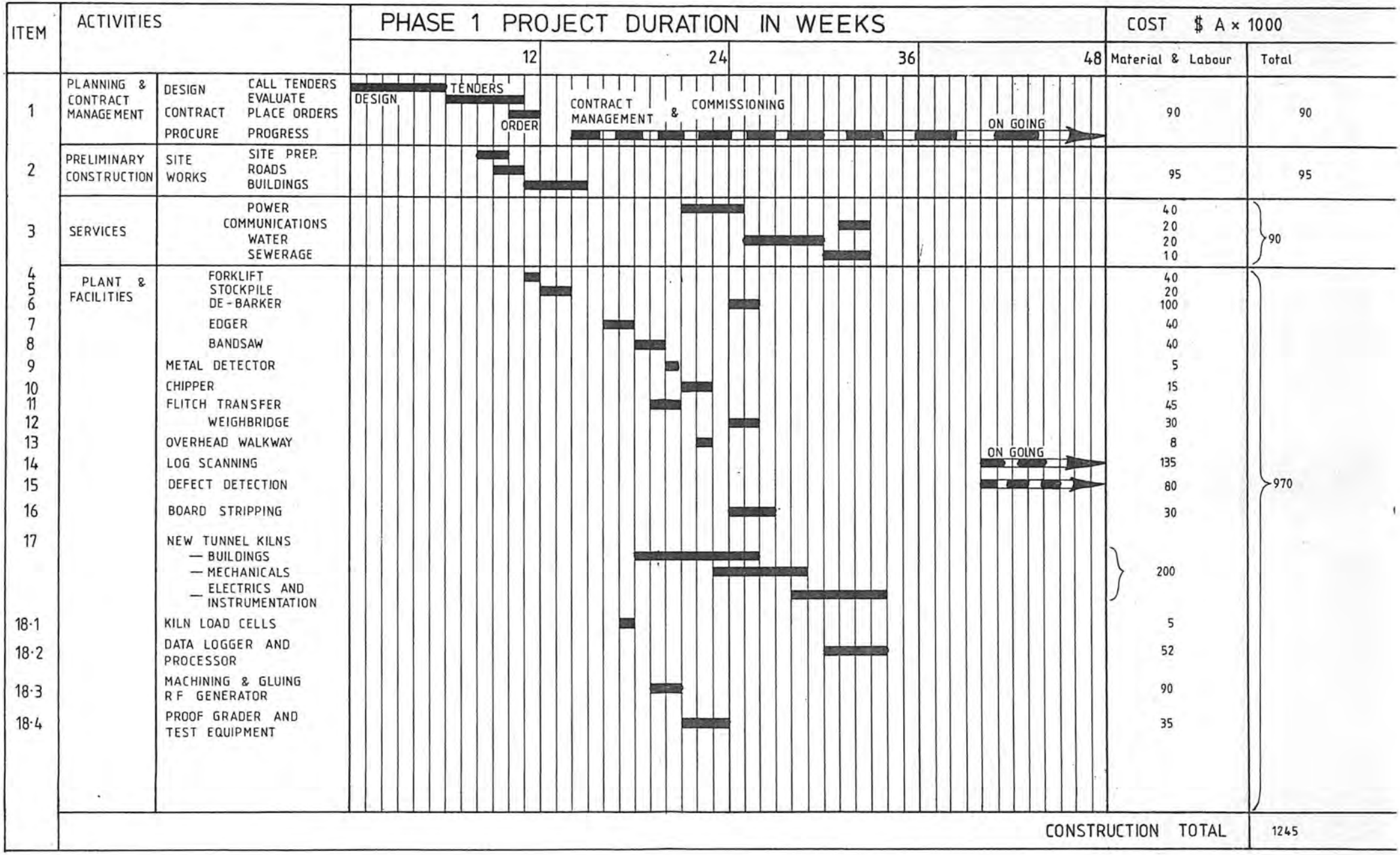
Salaried staff	30000 x 1.5	=	45,000
Wages employees	20000 x 1.5	=	30,000

   The factor 1.5 is to cover normal payroll overheads. It does not allow for general overheads such as the provision of transport, accommodation or for head office costs.

5. Inflation of wages has been provided for at 8% per annum.

PHASE 1 - CONSTRUCTION PLANNING PROGRAM

ATTACHMENT 4



ATTACHMENT 5

RESEARCH PROGRAM

Stage 1 SAWMILL OPERATIONS

(a)	Storage of regrowth logs. Stockpile management	JUNE 87
(b)	Breakdown of regrowth logs.	
	(i) Small log conversion using existing overhead beam.	JUNE 86
	(ii) Optimizing sawing patterns using 3D optical scanning system.	JUNE 88
(c)	Resawing of Flitches.	
	(i) Improved recovery from curved flitches using curved sawing techniques.	JAN 87
	(ii) Improved recovery of higher grade material using ultrasonic defect detection.	DEC 88

Stage 2 SEASONING OPERATIONS

(a)	Tunnel kiln design and schedules. Jarrah	DEC 86
(b)	High temperature kiln schedules. Jarrah	DEC 86
(c)	Other species	DEC 87

Stage 3 PRODUCT DEVELOPMENT & MARKETING

(a)	Mechanical properties and grade specifications updating for regrowth timber.	JUNE 87
(b)	Gluing techniques for regrowth timbers.	DEC 87
(c)	Regrowth timber suitability for veneer production.	DEC 86
(d)	Regrowth timber suitability for furniture/cabinet production.	JUNE 87

Stage 4 WOOD RESIDUE - UTILISATION

(a) Literature search and market analysis.	DEC 86
(b) Expansion to other industries of the industrial application of power generation using small scale fluidised bed wood combustor.	DEC 87
(c) Products of pyrolysis. Activated carbon. Charcoal	DEC 88
(d) Wood distillate. Natural preservatives. Stains. Pharmaceutical Products. Industrial Products.	JUNE 89 and ongoing

ATTACHMENT 6

GLOSSARY

Ambient Temperature	Referring to the natural temperature conditions at a given place and time.
Appearance Timber	Grades of timber which meet aesthetic rather than structural specifications.
Bandsaw	An endless, belt-like blade of steel, toothed on one or both edges, which is used to saw timber.
Cant	A thick piece of timber with one or more flattened surfaces; sawn from a log and intended for resawing.
Charge	The quantity of timber required to fill a timber seasoning kiln.
Chipper-Canter	A machine which uses chipping heads to produce one or more flat faces on a log. The resultant cant is intended for further manufacture into timber, usually by sawing.
Defect	An irregularity in timber that lowers its strength, durability, appearance or utility.
Degrade	Generally, in timber and other forest produce, any process that lowers the value for any purpose. More particularly, in timber, a reduction in grade in timber from drying or faulty processing.
Distillation	Separation of chemical deposits from wood using heat.
Dressing	Finish by planing or otherwise smoothing one or more surfaces.
Durability	The resistance of timber to the effects of decay and insect attack. It can be natural or artificially applied.
Ecologizer	A mobile chipper-canter intended for use in the forest.
Edger	A machine used for squaring timber or cutting wide boards into several narrow ones.

Edge Gluing	Joining pieces of timber edge-to-edge to provide laminated timbers of sufficient width.
End Point Moisture Content	The final moisture content required in a charge of timber being kiln dried.
Equilibrium Moisture Content (e.m.c.)	The moisture content at which timber neither gains nor loses moisture when subjected to given conditions of humidity and temperature.
Face Gluing	Joining pieces of timber face-to-face to provide laminated timbers.
Fibre Saturation Point (f.s.p.)	The moisture content at which all free moisture in wood has been removed but at which the cell walls are still saturated.
Flitch	A large piece of sawn log intended for further cutting. A flitch is sawn on two surfaces at least.
Fluidised Bed	A fluidised bed is a hot bed of sand particles which behaves as a fluid as air is forced through the bed from below. The air flow agitates the particles and they become mobile, circulating within the bed. The pressure at the bottom of the bed, as with a fluid, is proportional to the bed depth.
Gasifier	A device for producing gas from wood waste using the principle of a fluidised bed. The process depends on the temperature and the air to sawdust ratio during operation.
Grade Specifications	Specifications used for sorting timber in order of quality.
Green Timber	Timber still containing free moisture in its cell cavities.
Growth Stresses	Natural internal tension and compression forces developed in the standing tree, as the result of the growth and enlargement of tissues, or other causes.
Hardwood	Wood from trees classified botanically as Angiosperms. Most hardwood trees are broad leaved, and the wood is pored. The term does not denote the relative hardness of the wood, though sometimes used in this sense.

Heartwood	The inner layers of wood which, in the growing tree, have ceased to contain living cells. It is generally darker in colour than sapwood, due to the deposition in the cell lumens of tannins, polyphenols, resin, etc.
High Temperature Kiln	Kilns which use temperatures in excess of $100^{o}C$
Mature Hardwoods	Timber from the original forest.
Mechanical Proof Grading	The act of evaluating timber strength by the application of a predetermined continuous bending load, by a proof grading machine.
Overstocking	The condition of a forest where the number of trees is too great to permit maximum growth.
Physical Properties	The properties of timber such as density, moisture content, modulus of rupture, modulus of elasticity, maximum crushing strength, shear, impact strength, hardness etc.
Progressive Tunnel Kiln	A long chamber holding a succession of timber stacks ranging from green at one end to dry at the other. Air is drawn in at the dry end and expelled from the green end. As the air moves through the kiln moisture is collected from the timber and the temperature drops. As a stack is removed from the dry end all remaining stacks are moved along and a green one is placed in the green end, thus maintaining a full chamber at all times.
Pyrolysis	Chemical decomposition of wood using heat.
Recovery	The amount of sawn timber expressed as a percentage of the log volume.
Regrowth Hardwoods	Immature hardwoods naturally or artificially regenerated
Rough Sawn	The condition of wood as it leaves the saw and without further processing.

Sapwood	The outer layers of the log which in the growing tree contain living cells. The sapwood is normally lighter in colour than heartwood.
Sawmill Conversion	The first stage. Converting logs to sawn timber, through a sawmill.
Seasoning	Drying timber to a moisture range appropriate to its end use requirements.
Softwood	Wood from trees classified botanically as Gymnosperms. Commercial timbers of this group are nearly all conifers. The term does not denote the relative softness of the wood.
Stripping	Stacking of timber for seasoning in layers separated by small pieces of sawn or dressed timber of rectangular or square cross section.
Surface Checking	A split in the surface of timber which is the separation of the fibres along the grain forming a fissure in the timber but not extending through the piece from one surface to another. It generally results from stresses set up in the timber during seasoning.
Sustained Yield	A method of management that implies continuous production from a forest at a balance between net growth and yield.
Transition Wood	A zone of wood between the sapwood and heartwood that has some of the properties of both.
Veneer	A thin sheet of wood produced by slicing or rotary cutting.
Wood Residue	The timber and parts of trees remaining in a sawmill, process plant or forest after conversion.