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CONSULTING REPORT

for

CHEMONICS INTERNATIONAL

Washington, DC

PROJECT: SAWMILL (Part 1 of 3)

PROJECT #: USAID 527-C-00-01-00091-00

November 2001

Background

This report presents four different simple sawmill configurations that can be used to evaluate the economic feasibility of building a sawmill in Colombia. The purpose of the sawmill would be to supply raw material to a flooring plant and a millwork plant. The information presented in this report and the associated spreadsheets are based on concepts, experiences, assumptions used in North America, and general information supplied by consultants with the Colombia Alternative Development (CAD) project, without any on site visits to the potential operation. The reader is therefore cautioned that this is a preliminary report and a great deal of effort must be further expended to evaluate, refine and update the assumptions that are used in the report in order to reach valid conclusions. The intention of the report is to only provide input to a pre-feasibility financial analysis of the project. If the initial financial evaluation of the project is positive, information in greater detail has to be developed.

In the author's experience, gained on five continents, the following can negatively impact on a project significantly:

- Making assumptions about the raw material that are not valid. This can range from not recognizing inherent problems in a raw material such a higher percentage compression wood in raw material from a given local, to making the wrong assumptions concerning the raw material size and potential grade yield. There is no substitute for actual field trials that simulate the entire future production process, using personnel with a broad range of experience to interpret the results.
- Assuming that one can quickly start up with the lack of infrastructure. This lack of infrastructure can include the lack of trained forest products personnel and managers, power, log suppliers, transportation, etc.
- Assuming that inexperienced employees, even though they are intelligent and technically trained, will perform as experienced mill hands.
- Assuming that sawmill equipment will perform at optimum level from the factory and therefore not fine-tuning the equipment once installed.

Lumber Manufacturing

The scenarios present are all derivatives of the same mill flow. Table 1 lists approximate mill costs for the four different scenarios while Table 2 lists the manning table for the sawmill labor. If one properly plans, purchases and installs the mill the very basic layout (Scenario 1) can evolve into a higher production mill with little effort. Or the flow diagram of the first scenario can be used independently as a low cost solution for processing lumber in more remote areas. A very general log distribution was included in the preliminary information. Based on this information and the desired production level a combination gang was recommended as the secondary breakdown. In North America hardwood logs less than 14 inches are usually not processed profitably in a sawmill. It is therefore recommended that the log supply be re-evaluated in the light of this information. For large hardwood logs a band resaw would be a preferable machine for the secondary breakdown.

Scenario 1 – This is a very basic sawmill consisting of a circular saw modular mill and a two saw edger. The mill would be capable of cutting 2.35 to 2.36 cubic meters per hour with a crew of 5 personnel.

The mill does not have a debarker, chipper or trim saw. Logs are placed on a mechanical infeed deck and are cross-transferred using chains. The basic mill unit is a modular mill unit (pre-assembled by the manufacturer) consisting of a log turner, carriage to transport the log past the saw, carriage feed, circular saw, off bearing belt and sawyers cab. The mill can either be designed as a stationary or mobile unit. The mobile units are designed to be moved every several weeks in order to be closer to the log resource. Normally mobile units are powered by diesel engines while the stationary ones are electric powered.

The log is sawn into flitches and boards on the headrig. A two saw edger is used to edge the flitches into boards. When a diesel engine is used to power the mill, the main power unit normally also powers the edger. Lumber handling can range from non-powered conveying rolls in the mobile operation, to powered conveyors at permanent installations. Installation costs of these mills is normally kept to a minimum. The mobile mills are normally located on a slight slope so that sawdust, slabs and edgings can be disposed of easily using gravity. When the waste piles get too large, the mill is moved. On a permanent foundation there must be method of moving the waste away from the mill. This usually consists of a series of floor conveyors.

The major advantage of this mill is:

- Low capital cost
- Not technically complicated
- Low manning requirements
- Simple maintenance

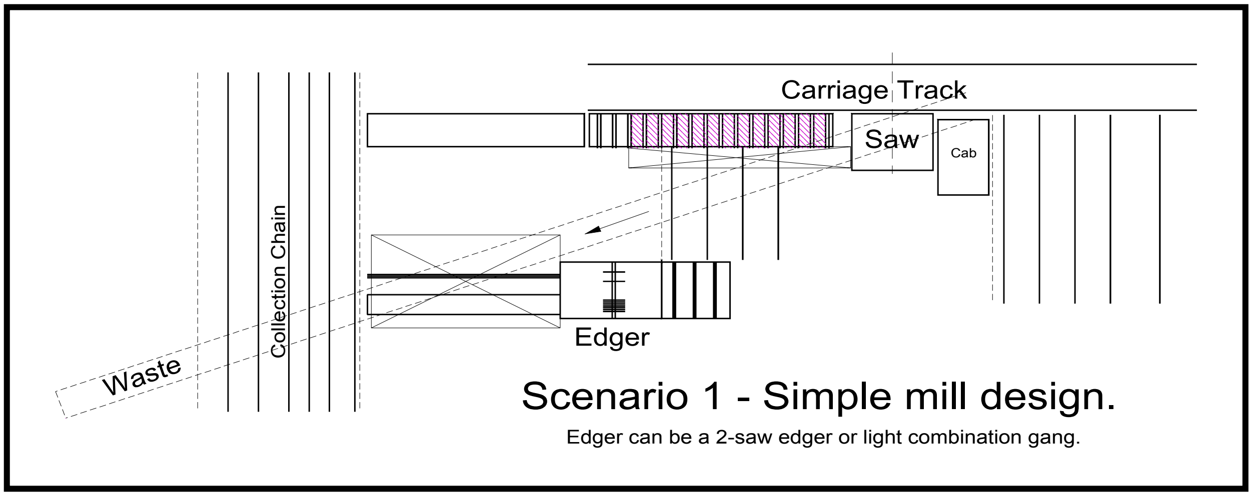
Negative aspects of the mill include:

- Low production because of no secondary breakdown and the need to sharpen the saw more often because the lack of a debarker.
- Lower yield due to the heavier kerf of the circular headsaw versus a bandsaw

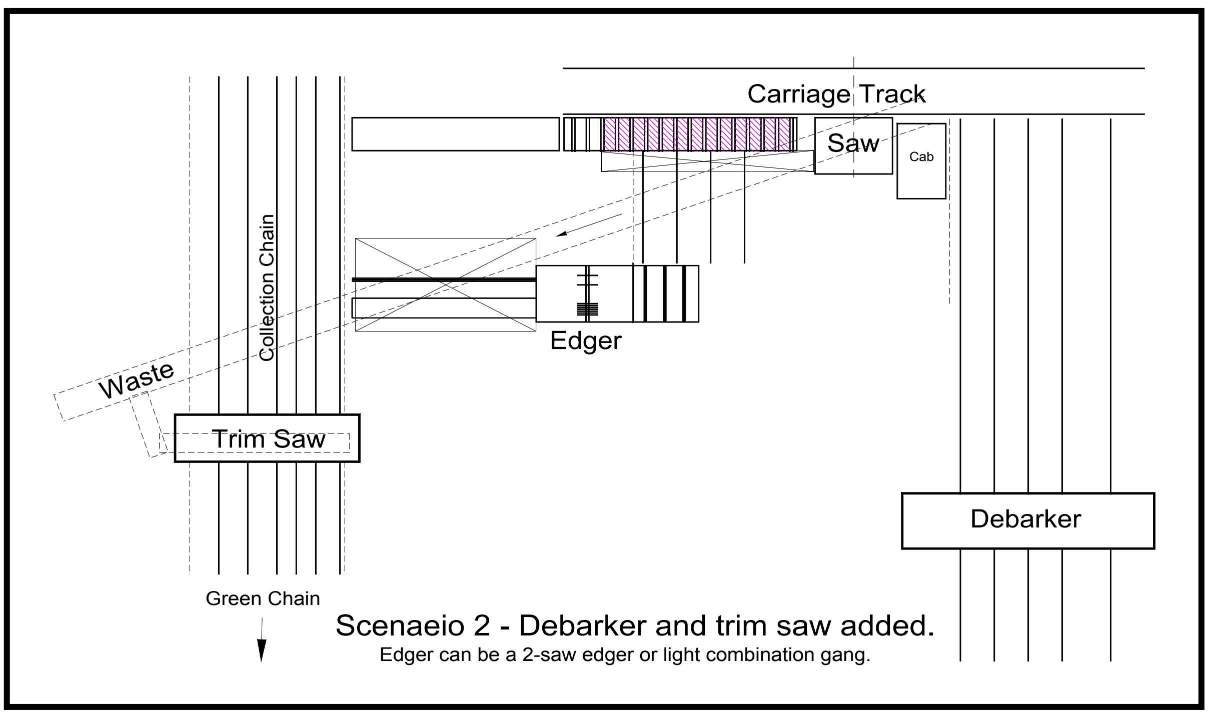
.

The productivity of these mills can be improved by insuring:

- Insure the log deck is continuously full of good sized logs (14 to 16 inch is ideal)
- Properly sizing the saw motor and carriage drive
- Insure there is an adequate method of removing the sawmill waste

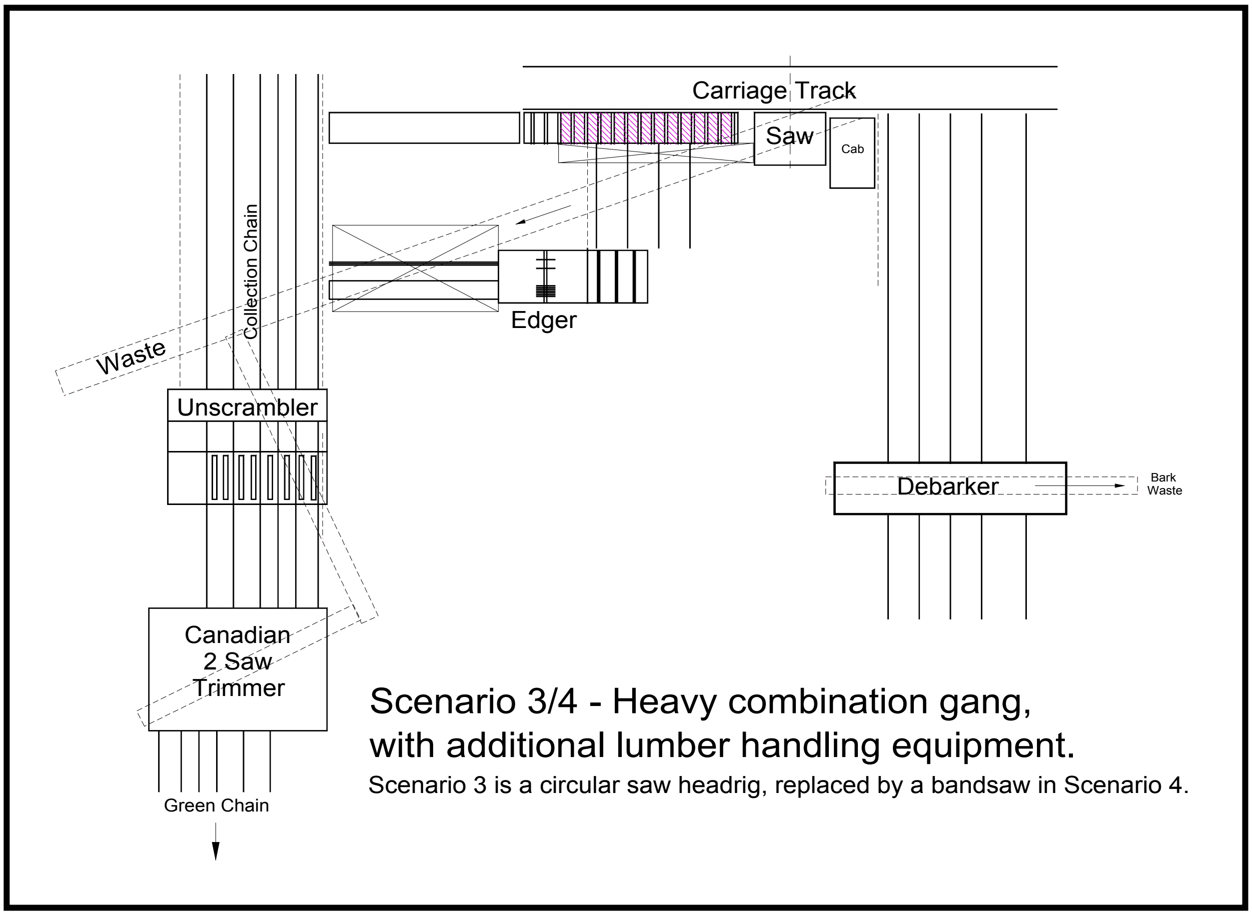


Scenario 2 – The general layout in the second scenario is very similar too the first. The primary breakdown of the mill is an upgraded circular modular sawmill utilized in the first scenario. Better log turning, faster dogging, higher saw horsepower and carriage speed contributes to the increased production.



A debarker has been added which during the debarking process also removes mud and rocks on the log surface that potentially dull the saw blade. An estimate used in the lumber industry is that a debarker increases production by a minimum of 10 percent due to less downtime attributed to saw sharpening. Also the debarker will allow the production of clean pulp chips from the slabs and edgings. The mill potential production capacity will be approximately 4.7 to 5.9 cubic meters per hour with a crew of 8. A small simple combination gang could be purchased to enhance productivity. In this mill the lumber is end trimmed. A chipper is added to process the slabs, edging strips and end trims into pulp chips. Also additional potential revenue can be realized if a market is found for the bark.

Scenario 3 – Productivity is increased by the replacement of the two-saw edger (or possibly a light duty combination gang) with a heavy-duty combination gang. The combination gang is used to process two sided cants and edge boards. By two siding smaller logs on the headrig, there will be a reduction in the average processing time per log, thus increasing the daily production.



Scenario 3/4 - Heavy combination gang,
with additional lumber handling equipment.
Scenario 3 is a circular saw headrig, replaced by a bandsaw in Scenario 4.

The mill has the potential to produce approximately 6.6 to 8.2 cubic meters per hour with a crew of 12. In order to handle the increased production heavier duty, more positive lumber and waste conveying equipment is needed. Installation costs will also rise with the heavier equipment.

Scenario 4 – Very similar to the third scenario except the circular headrig would be replaced by a band headrig. Using a band headrig versus a circular headrig would allow the recovery of 7 to 10 percent more lumber from the same log supply. Using a band headrig will increase both the capital cost (increase in the headrig cost as well as saw filing equipment) and the operating expenses of the mill including a saw filer and the marginal costs of the bandsaws versus circular saws. Band saw filing is not a simple skill to be mastered. A critical question for management to ask before deciding to install a bandmill is who will maintain the saws? The mill has the potential to produce approximately 6.6 to 8.2 cubic meters per hour with a crew of 12. In order to handle the increased production heavier duty, more positive lumber and waste conveying equipment is needed. Installation costs will also rise with the heavier equipment.

Other Scenarios

If the assumption in the future is that larger grade logs will be processed in the mill, and a band resaw is the anticipated secondary log breakdown machine, a layout similar to the second scenario would be appropriate with some slight modifications. The major modification is stretching the mill out so that later on a band resaw could be added with little downtime and disruption of the flow of the mill.

Projected Yield

The estimated yield for the circle mill is 40% and 45% for Scenario 4 using the band mill. Yield numbers can vary wildly based on incoming raw material, products, operator skill and sawing pattern.

Power Consumption In The Green Sawmill

In general it takes 400 kilowatts to produce one cubic meter of green lumber and approximately 240 kilowatts of electrical energy (excluding heating cost) to dry one cubic meter of lumber.

Fungal Anti-Stain Dipping

Fungi can degrade lumber in three different forms; molds, stains and decay. Also various wood boring insects can attack wood. The best way to avoid attack by these biological agents is to get the lumber dry as quickly as possible. If this can not be practically done lumber is treated with various chemicals. Most mills in the United States have gone to batch dipping systems. The reason behind this is to avoid skin contact with the chemicals and avoid equipment damage since most of the chemicals are extremely corrosive. A batch dipping system can be made from utilizing a reinforced concrete dip tank, with the interior coated with epoxy. To raise and lower the lumber a discarded forklift mast can be used.

If a batch system is not used a locally made dip system can be made to immerse the lumber in chemical after the trim saw prior to the green chain.

Lumber Drying

In order to make the lumber dimensionally stable it must be kiln dried before it is manufactured into furniture or millwork. Kiln dried lumber must also be stored in the proper environment in order to avoid moisture pick up. If you dry lumber at the sawmill site, you must plan to have a dry storage building. Depending on the climate (humidity) the building may need to be heated.

Fast drying species and species that are subject to attack by staining and or insect attack are normally kiln dried immediately after sawing. Slower drying species, species that are prone to checking and thicker stock are normally pre-dried prior to kiln drying. This is done to minimize drying cost. Pre-drying can range from air drying, to shed drying, to fan shed drying, to using a warehouse type predryer (a low temperature kiln). Lumber can rapidly degrade when exposed to the elements. Therefore some type of control is needed in order to avoid these financial losses. Thus air-drying has lost favor to the other forms of pre-drying.

Two suitable types of kilns are dehumidification kilns and steam heated kilns. The advantage of a dehumidification kiln is that a boiler is not required. However electrical consumption is much higher for a dehumidification kiln versus a steam fired kiln. For steam fired kilns, wood waste or a fossil fuel can fire a boiler. In North America, where labor is relatively expensive, an automatic system is used in supplying fuel to a wood fired boiler. This is the most expensive component of a wood fired boiler. Thus in North America wood fired systems only become economically feasible when the installed kiln capacity is above 380 cubic meters of lumber.

For the feasibility study use \$2225/m^3 for installed kiln capacity. This figure includes kilns, boiler, erection, concrete, providing service hook up, etc. Based upon an assumed species, lumber thickness distribution and drying times Table 3 indicates that 304 cubic meters of installed kiln capacity will be needed at an approximate cost of \$675,000. This is based on relatively small (approximately 70 cubic meter) kiln chambers, and all of the equipment imported from the US.

Lumber Surfacing

If the lumber produced from the sawmill will be used to feed a millwork plant and a flooring plant the lumber will have to be surfaced. The logical place to surface the lumber would be at the sawmill. New surfacing equipment from the United States is designed for surfacing at much higher production rates than needed for the project. Approximate cost for a new surfacing installation would be \$750,000, while utilizing adequate used equipment the cost could be \$200,000.

Operating Capital

Due to the fact that lumber manufacturing is an inventory intensive manufacturing industry there is a need for access to a large amount of operating capital. The operating capital is used to buy logs, and hold the inventory while it is being processed. A method of figuring your required operating capital is to take the total cash out lay to operate for a period time, when the logs are purchased to when money is received, and use this figure as the required operating capital. Typically this can range from 4 to 6 months. Long lead times on log purchases, long drying times, and slow payment can dramatically increase the required operating capital.

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CONSULTING REPORT

for

CHEMONICS INTERNATIONAL

Washington, DC

PROJECT: FLOORING PLANT (Part 2 of 3)

PROJECT #: USAID 527-C-00-01-00091-00

November 2001

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1) Background:

Chemonics International, Inc. based in Washington, DC and Ed Jerger & Associates, Raleigh, NC [further also referred to as "the consulting firm"] signed an agreement on November 16, 2001 to work together on the "Colombia Alternative Development" project. The tasks of the consulting firm are to prepare three separate studies for a sawmill, a flooring plant and a millwork plant. These studies are engineering proposals at the pre-feasibility level and should include the layouts, the equipment selection and investment information for determining the basic production costs.

For the flooring plant portion of the project, the contract between Chemonics International and Ed Jerger & Associates reads:

"FLOORING PLANT: The subcontractor will submit a report to Chemonics containing the plant lay-out with process flow, equipment selection and its assumptions, criteria and recommendations, capital costs, production and yield after considering learning curve. The report will provide suggestions for phased implementation and for reducing initial investment and risks."

Based on this, the consulting firm is submitting the following report.

NOTE: This report is part of a larger project. The entire report consists of three individual reports that are conceptually tied together. It is recommended that the reader familiarize himself/herself with the content of all three parts of this report. Certain, specific information that the reader is looking for may be covered in one of the other parts of this report.

2) Executive Summary:

The proposed flooring plant requires a building of about 2,629 m^2. A 2-stage implementation plan is suggested.
In stage 1 (approx. Year 0…2) the company should focus on producing unfinished strip flooring for North American markets. The 2 ¼" "Strip Flooring" makes up approx. 60% - 75% of the flooring market. Other marketable widths include 3 ¼"(83mm); 4" (102mm) and 6"(152mm), all random length material. The wider flooring products appear to be gaining in popularity in the USA and the European markets; both in unfinished and pre-finished form.
The design output of the plant is 114,000 linear meters of product per month, which equates to approximately 6,500 square meters of product per month. At a specific gravity of 0.6 for the average wood species this output will fill about 6.35 twenty-foot containers. The required lumber input is 284 m^3 per month with an overall plant yield of 55 percent. The investment cost for machinery is $710,900.00 for new equipment and the estimated capital expenditure for purchasing the same equipment on the used market is approximately $282,000.00.
After basic manufacturing skills have been acquired in the first two years, the company will add a pre-finishing line in stage 2 of the project. The machinery costs for stage 2 are $240,000.00. Purchasing the same equipment on the used market could reduce the investment to about $100,000.00.
Total project cost for new equipment in stage 1 and stage 2 is $950,900.00.

The following table serves as a reference to highlight the significant parameters of the project:

Flooring	Year	Products	Lumber Input/Year	Machine Costs	People
Stage 1	0- 2	Random length Strip Flooring	2,750 m^3	$665,892.00	16 +1
Stage 2	3-30	Pre-finished Strip flooring	3,000 m^3	$240,000.00	18 + 1

Table 1: Flooring – Project Summary

3) Basis for Discussion - Hypothesis:

A) Species under Consideration:

Dense, tropical hardwoods such as . Pouteria sp., Brossimum sp. and others will be used. For most cases, the specific gravity of these species can be expected to be 0.6 or higher.

B) Targeted Moisture Content (MC) for Flooring Products: 8 percent

C) Weight of Wood:

$$\text{Weight [lbs/ft}^3\text{]} = 62.4 \text{ [lbs/ft}^3\text{]} \times \text{specific gravity} \times (1 + \text{MC})$$

Formula 1: Weight of Wood

For a specific gravity of 0.6, the weight of the wood is 40.4 lbs/ft^3

D) Surface Quality of Flooring Products: 12 Knife Marks per Inch (KMPI)

The surface quality standard for flooring products in the USA is 12 KMPI. To meet these standards, the moulding machine (single knife finishing machine) has to be set at a feed speed of:

$$\text{Feed Speed [ft/min]} = (\text{Spindle RPM} \times \text{\# knives}) / (\text{KMPI} \times 12)$$

Formula 2: Feed Speed of Moulder

Feed Speed = (8,000 x 1) / (12 x 12) = 55.56 [ft/min] or approx. 17 meters/min

E) Constraint Machine: SIDEMATCHER

F) Capacity of Constraint Machine:

The machine that limits the total output of the plant is the moulding machine; which the flooring industry refers to as the "Sidematcher". On the average, flooring plants operate their "sidematcher" with a 75% efficiency rate, thus allowing a 25% PFD factor (PFD = Personal, Fatigue and Delay Time). It is also assumed that 1/2 hour per shift will be used for changeovers. Under these conditions [one shift = 8 hours; feed speed = 17 m/min; machine changeover time per shift = 1/2 hour; PFD factor = 25%] the production can be expected to be:

(17 m/min x 60 min/hour x 7.5 hours/shift) x 0.75 percent efficiency =
= 5,700 linear meters/shift

It goes without saying, that any one of these assumptions, such as changeover time, PFD factor, etc. can be challenged. These numbers reflect the experience of the consulting firm gained through working with flooring plants in the United States.

G) Dimensions of the Standard Flooring Product: 2 ¼ ″ x ¾″ (57 mm x 19 mm) The 2 ¼″ "Strip Flooring" makes up approx. 60% - 75% of the flooring market. Other marketable widths include 3 ¼″(83mm); 4″ (102mm) and 6″(152mm), all random length material. The wider flooring products appear to be gaining in popularity in the USA and the European markets; both in unfinished and pre-finished form.

H) Shipments:

The targeted production are shipments of 4…8 twenty foot containers per month. The following calculations assume that the weight limit of the container is reached before the cube is filled. In other words, the container will not be completely filled with products because the payload capacity will have been reached.

Payload for a 20-foot container: 28,000 lbs

Shipments by weight: 4 containers/month = 112,000 lbs/month
8 containers/month = 224,000 lbs/month

Shipments in Square Meters (Standard Product):

Shipments/month	Productweight/m^2	Shipments [m^2/month]
4 containers (20ft)	27.22 lbs/m^2	4,100 square meters
8 containers (20ft)	27.22 lbs/m^2	8,200 square meters

Table 2: Shipments in m^2 per month of 2 ¼″ x 19mm strip flooring

<u>4) Production Calculations:</u>

Hours per Shift: 8
Shifts per Day: 1
Workdays per Month: 20

NOTE: All estimates and calculations are based on conservative assumptions. With proper training of personnel and new equipment, a start-up operation should be able to reach these production levels within six month.
Further production increases can be achieved by applying various methods, such as:

- Increase in efficiencies (Reduction of PFD factor)
- Quicker changeovers on the bottleneck operation or improved scheduling resulting in fewer changeovers
- Focus on obtaining orders for the wider strip flooring products. Since the feed speed on the moulder is the same, more square meters of product is generated with wide products than with narrow products, given the same amount of time.
- etc.

Using the parameters specified in the hypothesis section of this report, the flooring plant will produce the following:

Output = 5,700 linear meters/day x 20 days/month = 114,000 lin. meters/month or 6,500 square meters/month

Wood with a specific gravity of 0.6 will fill 6.35 containers a month.

Lumber Requirements:

Sawmills in the United States generally have difficulties in selling their low grade boards and strip flooring plants use a lot of low grade lumber. Therefore, strip flooring plants in the US are a sought after customer by sawmills. Strip flooring plants generally purchase #2 Common lumber and 3A lumber.

Total Yield: **50…55 percent**
The total plant yield in strip flooring mills is fairly low. This should come as no surprise since flooring plants use low grade lumber.
However, the consulting firm has noticed that flooring plants in Central and South America (Costa Rica and Chile) often experience higher yields than their US counterparts. This is explained by the fact that many flooring mills in Central and South America buy their raw material on a log run basis. "Log Run" means that the secondary processor does not, or cannot, buy graded lumber, thus having to purchase the entire log. This may or may not be the case under the premises of this project in Colombia.

To continue with conservative estimates, the consulting firm has selected a total plant yield of 55 percent for this flooring mill. Therefore, the required lumber input into the plant on a monthly basis is (lumber thickness is a full 24 mm; length and width losses are considered in the total yield figure):

Lumber Input = [(114,000 m x 0.057 m) / 0.55] x 0.024 m) =
Lumber Input = 284 m^3 or 120,000 bft per month

5) Plant Design and Products

The flooring plant could be designed in two stages. In the first stage the mill would produce unfinished strip flooring for the US market. In the US, strip flooring that is sold in small quantities is generally marketed unfinished and the market for unfinished strip flooring is large. After solid relationships with customers have been established (2 to 3 years), the flooring mill may want to consider expanding its operation, during stage 2 of the project, and invest in a pre-finishing line. However, pre-finishing lines are fairly expensive and, considering the volumes that are produced, the Net Present Value may not be big enough to justify such an investment.
Important Note: Pre-finished flooring has a slightly different profile. Material must be pre-sorted and designated to this product prior to the side matcher.

6) Plant Layout and Process Flow:

Please see the following page for the layout of the flooring plant.
Ideally, the boards coming into the flooring mill should be planed. However, the mill could process rough lumber. The process flow is the following: Rip Saw, Side Matcher, Grading and Defect Saws, End Matchers, Product Grading Area, Nesting, and Pre-Finishing.

7) Investment Costs

The following table lists the investment in machinery for the millwork plant. Real estate costs and costs for a building are not considered.

The prices for machines are based on quotes obtained from US machinery manufacturers, or the US sales office of foreign manufacturers (side matcher), during the month of November 2001 and are stated in US dollars. Prices do not include:

- Shipping costs of machinery to Colombia
- Import duties or local taxes
- Cost for electrical transformers (if needed)

- Cost for pouring foundations for heavy equipment (i.e. planer, moulder, etc.)
- Costs for electrical wiring from the sub-station to the machines
- Costs for installing ductwork, pneumatic lines and other auxiliary service connections
- Costs for installation, alignment and start-up of machinery

The following machinery was selected (Please refer to the plant lay-out for line items A through H):

Item: A / Rip Saw Line

- **Rip Saw line** consists of a manually fed in-feed system with laser light guides & stand. Material guided by operator into prefixed slots in gang saw to produce multiple fixed widths as needed for end product. This system is simple and easily maintained. Since the end product remains consistent as to width requirements, any changes to the position of the laser guide lights are minimal.

- **Fixed Arbor 31″ Gang Rip Saw** with spare arbor sleeve, transfer cart and spacers. Saw arbor sleeve is pre-arranged with specific gaps or spaces between blades as need for production. Rough, blank boards pass through saw blades to create fixed width blanks to feed into side matcher. This process removes wane, warp and poor material from the edges of rough boards. A non-moving blade system was chosen for ease of maintenance and product consistency.

- **30″x 16′ Out-Feed Conveyor –** Conveyor can be belt or roller driven. The roller type conveyor is better suited for the rough material used in this process. Although feed material will not exceed eight (8′) a longer out-feed conveyor is used to provide safety for the off-bearer. If a second board is feed into the rip saw, while other material still awaits removal, the extra length allows for an adequate safety period to remove waiting material.

- **14″ x 36′ Waste Belt –** Belt is used to remove unwanted scrape and edgings created from trimming the rough boards through the *Fixed Arbor Gang Rip Saw*. Commonly a pit or gutter is constructed in the floor to allow placing this conveyor below the level surface of the manufacturing plant. Placing steel grates across the opening allows for unrestricted access to all areas around the machinery.

Total Machinery Allowance for Rip Saw Area: $110,500.00

Item: B / Side Matcher (Molder)

- **220mm Wide Molder –** Used to produce desired flooring profile on top, bottom and both, right & left sides, of wood blanks. Machine configuration of spindles should be Bottom; Right; Left; Top; Bottom. Allowance for spare tooling is necessary and considered in the total price.

- **Hopper In-Feed System or a Lateral In-Feed Deck** is positioned in front of the molder to allow for consistent feeding of the machine, utilizing its full capacity.

- **Out-feed Belts** should be 355mm in width and 10 –11 meters in length. Two belts should be employed, one inclined to speed up and remove material from exit area of the side matcher and the second (leveled) to allow space for two (2) manual chop saw operators. Chop saw operators cut and grade material as needed before end matching.

- **Manual chop saws (2) –** Up cut saws are recommended for safety reasons and economy.

- **Profile Grinder –** Located in grinding room and used to produce and sharpen profile knives for side matcher.

Total Machinery Allowance for Molder Area: $173,800.00

Item C: End Matching

- **One Groove Unit** with trim & groove saws on separate motors.

- **One Tongue Unit** with trim saw and separate upper & lower "tongue" units. Units include powered chain bed drives. Capacity is 4 meters in length and 185mm in width. (Quote includes allowance for spare tooling.)

- **Cross Conveyors –** Two 7.5 meter in-feed & out-feed conveyors.

Total Machinery Allowance for End Matching Area: $164,600.00

Item D: Nesting, Sorting & Packaging

- **Sorting Line** for sorting and nesting of graded material before shipping. Line has capacity for later installation of camera scanning for grade marks and automated sorting by grades. Installation should have a minimum of two (2) nesting stations with the ability to add future stations.
- **Banding Machine** for plastic strapping of finished bundles of flooring. Foot pedal operated when material passes under strapping arm.

Total Machinery Allowance For Nesting Area: $62,000.00

Item E: Waste Grinding Machine

- **Horizontal Grinder** for grinding both edgings from rip area and end cuts from chop saws, end matcher etc. Machine should have capacity to dispose of 5,000 square feet of waste material per shift.

Total Allowance for Waste Grinding: $55,000.00

Item F: Compressed Air Station

- **Rotary Air Compressor W/Dryer –** Capacity as needed to meet machinery manufacturers' air requirement recommendations (+ 25%). Air should be dried to avoid water problems, typically related with an installation in areas of high relative humidity of ambient air. Allowance for line drop in air transfer pipe needs to be considered!

Total Allowance for Compressed Air Station: $20,000.00

Item G: Dust Collection

- **Dust Cyclone –** Exterior mounted cyclone with collection area to remove all dust and scrap grindings from production area. Cyclone should be mounted in such a way to allow for truck removal of scrap. Allowances for dust extraction pipes to machinery is included.

Total Allowance for Dust Collection: $80,000.00

Item H: ***Total Allowance for Forklift: $45,000.00***

Total Machinery Allowances for Flooring Plant (Stage 1):

$710,900.00

Summary of Stage 1 of Flooring Plant:

EQUIPMENT	*PRICE (new)*	*PRICE (used)*	*Approx. HP*
Rip Saw Line w/manual in-feed Multi-blade rip saw & out-feed belt	$110,500.00	$45,000.00	80
Side Matcher & Profile Grinder	$173,800.00	$70,000.00	77
End Matcher w/conveyors	$164,600.00	$66,000.00	40
Nesting, Sorting Line	$62,000.00	$25,000.00	10

Compressor with air dryer	$20,000.00	$6,000.00	50
Dust collection system – bag house, fans and ductwork	$80,000.00	$30,000.00	100
Wood waste grinder with conveyors	$55,000.00	$22,000.00	125
Forklift	$45,000.00	$18,000.00	
TOTAL for STAGE 1	**$710,900.00**	**$282,000.00**	**482**

Table 4: Investment Cost for Stage 1 of Flooring Plant

Stage 2 of Flooring Plant:

EQUIPMENT	*PRICE (new)*	*PRICE (used)*	*Approx. HP*
UV Finishing Line	$240,000.00	$100,000.00	100
TOTAL for STAGE 2	**$240,000.00**	**$100,000.00**	**100**

Table 5: Investment Cost for Stage 2 of Flooring Plant

Total Cost for Flooring Plant

EQUIPMENT	*PRICE (new)*	*PRICE (used)*
TOTAL (Stage 1 and 2)	**$950,900.00**	**$382,000.00**

Table 6: Total Investment Cost for Flooring Plant

8) Conclusions and Suggestions:

a) The consulting firm recommends that a woodworking cluster area should be developed in a certain region of Colombia. In this cluster area a small sawmill (as proposed in this report) would supply kiln-dried lumber to millwork plant(s) and flooring plant(s). The sawmill should also operate a planer, thus eliminating the need for having this fairly expensive piece of equipment installed in the secondary wood processing plants (millwork and flooring plants).

b) It is highly recommended that the project budget should include a line item for hiring an experienced person to supervise installation, start-up and training for the flooring mill. This person should be hired for a minimum of 4 months and the person should have a proven track record having successfully completed similar tasks, preferably overseas.

A good source for finding such an individual is the "Corps of Craftsmen". The "Corps of Craftsmen" is managed through the Forest and Wood Products Institute of "Mount Wachusett Community College" in Gardner, Massachusetts. The college received a grant from the National Science Foundation to organize and maintain a roster of retired woodworking professionals that are willing to share their experiences. The college pays the craftsmen while they are on an assignment and covers their insurance. The college charges the client a rate of US$200.00 per day and all living and travel expenses for the craftsmen are the responsibility of the client. For more information on the "Corps of Craftsmen", please contact Mr. Ken Hanson at (978) 632-6600 ext. 320 or send an e-mail to khanson@mwcc.mass.edu.

---- End of "FLOORING PLANT" Report ----

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CONSULTING REPORT

for

CHEMONICS INTERNATIONAL

Washington, DC

PROJECT:	**MILLWORK PLANT (Part 3 of 3)**
PROJECT #:	**USAID 527-C-00-01-00091-00**

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1) Background:

Chemonics International, Inc. based in Washington, DC and Ed Jerger & Associates, Raleigh, NC [further also referred to as "the consulting firm"] signed an agreement on November 16, 2001 to work together on the "Colombia Alternative Development" project. The tasks of the consulting firm are to prepare three separate studies for a sawmill, a flooring plant and a millwork plant. These studies are engineering proposals at the pre-feasibility level and should include the layouts, the equipment selection and investment information for determining the basic production costs.

For the millwork portion of the project, the contract between Chemonics International and Ed Jerger & Associates reads:

"MILLWORK PLANT: The subcontractor will submit a report to Chemonics containing the plant lay-out with process flow, equipment selection and its assumptions, criteria and recommendations, capital costs, production and yield after considering learning curve. The report will provide suggestions for phased implementation and for reducing initial investment and risks."

Based on these conditions, the consulting firm is submitting the following report.

NOTE: This report is part of a larger project. The entire report consists of three individual reports that are conceptually tied together. It is recommended that the reader familiarize himself/herself with the content of all three parts of this report. Certain, specific information that the reader is looking for may be covered in one of the other parts of this report.

2) Executive Summary:

The proposed millwork plant requires a 1,996 m^2 building. A 2-stage implementation plan is suggested.
In stage 1 (approx. Year 0…2) the company will produce S-4-S dimension parts for the furniture industry and linear mouldings. The design output of the plant is 82,000 linear meters of product per month (three to five 20 foot containers) and the required lumber input is 230 m^3 per month. The investment cost for machinery is $788,500.00 for new equipment and the estimated capital expenditure for purchasing the same equipment on the used market is approximately $353,000.00.
After basic manufacturing skills have been acquired in the first two years, stage 2 of the implementation phase will then focus on adding more value to the products that are manufactured. The company will expand its product line into edge-glued panels, kitchen cabinet doors and specialty products for the building industry.
The machinery costs for stage 2 are $83,000.00. Purchasing the same equipment on the used market could reduce the investment to about $37,000.00.
Total project cost for new equipment in stage 1 and stage 2 is $871,500.00.

The following table serves as a reference to highlight the significant parameters of the project:

Millwork	**Year**	**Products**	**Lumber Input/Year**	**Machine Costs**	**People**
Stage 1	0- 2	Furniture Parts Linear Mouldings	2,750 m^3	$788,500.00	15 +1
Stage 2	3-30	Furniture Parts Linear Mouldings Edge-Glued Panels Cabinet Doors Specialty Products	3,000 m^3	$83,000.00	20 + 1

Table 1: Millwork – Project Summary

3) Basis for Discussion - Hypothesis:

B) Species under Consideration:

- "Aliso" (Alnus jorullensis): Specific Gravity 0.31 – 0.45
- "Nogal cafetero" (Cordia alliodora): Specific Gravity 0.47
- "Chingale" (Jacaranda copaia): Specific Gravity 0.35 – 0.40

B) Targeted Moisture Content (MC) for Millwork Products: 8 percent

C) Weight of Wood:
The specific gravity of these three species ranges from 0.31 to 0.47 and the lower and the upper end weights of these species are:

$$\text{Weight } [lbs/ft^3] = 62.4\ [lbs/ft^3] \times \text{specific gravity} \times (1 + MC)$$

Formula 1: Weight of Wood

For a specific gravity of 0.31, the weight of the wood is 20.9 lbs/ft^3
For a specific gravity of 0.47, the weight of the wood is 31.7 lbs/ft^3

D) Surface Quality of Millwork Products: 16 Knife Marks per Inch (KMPI)
The upper end surface standard for millwork products in the USA is 16 KMPI. To meet these standards, the moulding machine (single knife finishing machine) has to be set at a feed speed of:

$$\text{Feed Speed } [ft/min] = (\text{Spindle RPM} \times \#\ \text{knives}) / (\text{KMPI} \times 12)$$

Formula 2: Feed Speed of Moulder

Feed Speed = (8,000 x 1) / (16 x 12) = <u>41.67 [ft/min] or approx. 13 meters/min</u>

E) Constraint Machine: MOULDER

F) Capacity of Constraint Machine:
The machine constraining the total output of the plant is the moulding machine. On the average, millwork plants operate their moulders with a 75% efficiency rate, thus allowing a 25% PFD factor (PFD = Personal, Fatigue and Delay Time). It is also assumed that 1 hour per shift will be used for profile changeovers. Under these conditions [one shift = 8 hours; feed speed = 13 m/min; machine changeover time per shift = 1 hour; PFD factor = 25%] the production can be expected to be:

(13 m/min x 60 min/hour x 7 hours/shift) x 0.75 percent efficiency =
= <u>4,100 linear meters/shift</u>

It goes without saying, that any one of these assumptions, such as changeover time, PFD factor, etc. can be challenged. These numbers reflect the personal experience of the consultant with millwork plants and the numbers are well suited for use in a pre-feasibility study.

G) Dimensions for the Average Millwork Product: 3" x ¾"
For the most part, millwork plants rip for five to ten different rip sizes (= width sizes). Rip sizes generally range from 1 7/8 " to 5 ¾".
Lumber thickness that is typically processed in a hardwood millwork plant is 4/4 lumber. The finished thickness using 4/4 lumber is ¾". However, 5/4 and 6/4 lumber is also frequently used. To consider the "worst case" production scenario all further calculations are based on using 4/4 lumber.
A representative product (3" x ¾" or 76 mm x 19 mm) was selected to estimate the output of the plant. One linear meter of the representative product weighs between 1.071 lbs (Specific Gravity: 0.31) and 1.625 lbs (Specific Gravity: 0.41).

H) Shipments:

The targeted production are shipments of 4…8 twenty foot containers per month. The following calculations assume that the weight limit of the container is reached before the cube is filled. In other words, the container will not be completely filled with products because the payload capacity will have been reached.

Payload for a 20-foot container: 28,000 lbs

Shipments by weight: 4 containers/month = 112,000 lbs/month
8 containers/month = 224,000 lbs/month

Shipment in Linear Meters (Representative Product):

Sp. Gravity	Weight/linear meter	Shipments [lin. meters/month]
0.47	1.625 lbs.	69,000 lin. meters
0.31	1.071 lbs.	105,000 lin. meters

Table 2: Shipment of 4 containers/month (112,000 lbs. of product)

Sp. Gravity	Weight/linear meter	Shipments [lin. meters/month]
0.47	1.625 lbs.	138,000 lin. meters

0.31	1.071 lbs.	210,000 lin. meters

Table 3: Shipment of 8 containers/month (224,000 lbs. of product)

4) Production Calculations:

Hours per Shift: 8
Shifts per Day: 1
Workdays per Month: 20

NOTE: All estimates and calculations are based on conservative assumptions. With proper training of personnel and new equipment in the plant, a start-up operation should be able to reach these production levels comfortably within less than four month.

Further production increases in a millwork plant can be achieved by applying various methods, such as:

- Increase in efficiencies (Reduction of PFD factor)
- Quicker changeovers on the bottleneck operation or improved scheduling resulting in fewer changeovers
- Manufacturing the low price products with only 12 KMPI. This would be in compliance with the lower end of the accepted quality standard for moulding products.
- Focus on obtaining orders for wider products, such as crown mouldings, doorframes, etc. Since the feed speed on the moulder is the same, more product volume is generated with wide products than with narrow products in the same amount of time.
- Running a double pattern on the moulder.
- Etc.

Using the parameters specified in the hypothesis section of this report, the millwork plant will produce the following:

Output = 4,100 lin. meters/day x 20 days/month = 82,000 lin. meters/month

Wood with a high specific gravity (0.47) will fill 4.75 containers a month and with the lighter species (sp. gravity: 0.31) 82,000 lin. meters will fill approximately 3.12 containers.

Lumber Requirements:

Lumber yields are highly dependent on the number of products that are in a given cutting bill. It is common practice in the millwork industry to rip up to seven different widths on the ripsaw at any given time. Also, as a rule of thumb, the greater the length variety of products on the cut-off saw, the higher the yield. A well-balanced distribution of short, medium and long product lengths further helps to increase yields.

The following information represents data from US hardwood millwork plants, processing 50 percent #2 Common Lumber and 50 percent of #1 Common Lumber and Select Lumber of mostly wane-free boards. Yield figures for hardwoods grown in Colombia may vary significantly from yields for US hardwoods. This may hold especially true for lumber processed from log runs and not graded to grading rules, such as NHLA rules.

Considering the above parameters, i.e. multiple rip widths, great length distribution, etc., the following yields would apply to a US hardwood millwork plant:

Rip Yield:	85 percent
Cross Cut Yield:	80 percent
Moulder Yield:	95 percent

Total Yield: **(0.85 x 0.80 x 0.95) x 100 = <u>65 percent</u>**

Therefore, the required lumber input into the plant on a monthly basis is (lumber thickness is a full 24 mm; length and width losses are considered in the total yield figure):

Lumber Input = [(82,000 m x 0.076 m) / 0.65] x 0.024 m) =

<u>Lumber Input = 230 m^3 or 97,500 bft per month</u>

<u>5) Plant Design and Products</u>

The millwork plant should be designed taking a two-stage approach – first, a basic millwork operation, which will later on expanded by adding operations that add more value to the products. Initially, the focus should be on gaining experience in cutting up local wood species, improving lumber yields and producing products that consistently meet customer demands with regard to quality and delivery times. The Chilean millwork industry is a great success story that was based on taking this approach. After about two years or so, when the learning curve has reached the plateau for efficient processing, the company should be in a position to manufacture products that require additional skills. During the first two years in business (Stage 1), it is recommended that the millwork operation produce two groups of products:

- Furniture Dimension Stock, S-4-S — 60% of total production
- Linear Mouldings — 40% of total production

On or about the 3rd year, the company should add additional machinery to increase the value of the products it manufactures (Stage 2). These value-added processes require solid skill levels in lumber cut-up processes and additional skills for each of the processes that are being added. By then, the company should have experienced a steady increase in lumber yields obtained through better processing techniques and adjustments to the product mix. This means, that the company should be able to ship more products with the same amount of lumber delivered to the plant. At this time, it is suggested that the company may produce the following products:

- Furniture Dimension Stock — 15% of total production
- Linear Mouldings — 35% of total production
- Edge Glued Panels for the Furniture Industry — 15% of total production
- Kitchen Cabinet Doors — 25% of total production
- Products for the Building Industry — 10% of total production

Ultimately, the decision for the most suited products will be greatly influenced by the then known distribution of products that the lumber naturally yields and the current market conditions!

6) Plant Layout and Process Flow:

Please see the following page for the layout of the millwork plant.

The process flow is:

Planer

Ripsaw

Cross-Cut Area

Moulder

Clamp Carrier

Value Added Processing Area

7) Investment Costs

The following table lists the investment in machinery for the millwork plant. Real estate costs and costs for a building are not considered.

The prices for machines are based on quotes obtained from US machinery manufacturers, or the US sales office of foreign manufacturers (moulder), in the month of November 2001 and are stated in US dollars. Prices do not include:

- Shipping costs of machinery to Colombia
- Import duties or local taxes
- Cost for electrical transformers (if needed)
- Cost for pouring foundations for heavy equipment (i.e. planer, moulder, etc.)
- Costs for electrical wiring from the sub-station to the machines
- Costs for installing ductwork, pneumatic lines and other auxiliary service connections
- Costs for installation, alignment and start-up of machinery

Stage 1 of Millwork Plant:

EQUIPMENT	***PRICE (new)***	***PRICE (used)***	***Approx. HP***
Planer with tilt hoist, infeed and outfeed chains	$200,000.00	$100,000.00	85
Ripsaw with infeed and pull chain	$131,000.00	$55,000.00	80
Cross-cut area with 4 manual chop saws, tilt hoist, infeed, outfeed chains and turntable sorting station	$77,500.00	$32,000.00	50
Saw filing equipment	$30,000.00	$10,000.00	7
Moulder (5 spindles, 40 m/min) with knife grinder and spare tooling	$150,000.00	$80,000.00	50
Compressor with air dryer	$20,000.00	$6,000.00	50
Dust collection system – bag house, fans and ductwork	$80,000.00	$30,000.00	100
Wood waste grinder with conveyors	$55,000.00	$22,000.00	125
Forklift	$45,000.00	$18,000.00	--
TOTAL for STAGE 1	**$788,500.00**	**$353,000.00**	**547**

Table 4: Investment Cost for Stage 1 of Millwork Plant

Stage 2 of Millwork Plant:

EQUIPMENT	*PRICE (new)*	*PRICE (used)*	*Approx. HP*
Semi automated clamp carrier with glue spreader and pump for glue drums	$37,000.00	$15,000.00	10
Raised panel door system with pneumatic clamping table	$21,000.00	$10,000.00	7
Miscellaneous woodworking equipment for specialty products (table saw, router, etc.)	$25,000.00	$12,000.00	25
TOTAL for STAGE 2	**$83,000.00**	**$37,000.00**	**42**

Table 5: Investment Cost for Stage 2 of Millwork Plant

Total Cost for Millwork Plant

EQUIPMENT	*PRICE (new)*	*PRICE (used)*
TOTAL (Stage 1 and 2)	**$871,500.00**	**$390,000.00**

Table 6: Total Investment Cost for Millwork Plant

8) Conclusions and Suggestions:

a) The consulting firm recommends that a woodworking cluster area should be developed in a certain region of Colombia. In this cluster area a small sawmill (as proposed in this report) would supply kiln-dried lumber to millwork plant(s) and flooring plant(s). The sawmill should also operate a planer, thus eliminating the need for having this fairly expensive piece of equipment installed in the secondary wood processing plants (millwork and flooring plants).

b) In Stage 2 of the millwork plant, investment in a second moulder should be considered. This second moulder could certainly be a used machine. This machine would be used to prepare the stock for the clamp carrier and the other value-added processes. The output of the plant could be almost doubled with the single addition of a second moulder and monthly shipments could easily exceed six 20 foot containers a month.

c) It is highly recommended that the project budget should include a line item for hiring an experienced person to supervise installation, start-up and training for the millwork plant. This person should be hired for a minimum of 4 months and

the person should have a proven track record having successfully completed similar tasks, preferably overseas.
A good source for finding such an individual is the “Corps of Craftsmen”. The “Corps of Craftsmen” is managed through the Forest and Wood Products Institute of “Mount Wachusett Community College” in Gardner, Massachusetts. The college received a grant from the National Science Foundation to organize and maintain a roster of retired woodworking professionals that are willing to share their experiences. The college pays the craftsmen while they are on an assignment and covers their insurance. The college charges the client a rate of US$200.00 per day and all living and travel expenses for the craftsmen are the responsibility of the client. For more information on the “Corps of Craftsmen”, please contact Mr. Ken Hanson at (978) 632-6600 ext. 320 or send an e-mail to khanson@mwcc.mass.edu.

d) It is the experience of the consulting firm that start-up operations in the secondary wood industry can fail because they are over-capitalized. The millwork industry is a low margin business and every effort should be made to reduce expenses. One source for reducing the initial investment cost, and, thus the risk of the project, is in machinery purchases. Decisions for purchasing some equipment on the used market (i.e. planer) may have a very significant impact on the Net Present Value of the project, especially since these cash flows occur in year zero.

---- End of “MILLWORK PLANT” Report ----