Development Document for
Proposed Effluent Limitations Guidelines
and New Source Performance Standards
for the

WET STORAGE, SAWMILLS, PARTICLEBOARD AND INSULATION BOARD

Segment of the

TIMBER PRODUCTS PROCESSING

Point Source Category

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

AUGUST 1974

DEVELOPMENT DOCUMENT

for

EFFLUENT LIMITATIONS GUIDELINES

and

NEW SOURCE PERFORMANCE STANDARDS

for the

WET STORAGE, SAWMILLS, PARTICLEBOARD AND INSULATION BOARD SEGMENT OF THE TIMBER PRODUCTS PROCESSING POINT SOURCE CATEGORY

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August 1974

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ABSTRACT

A study was made of the timber products processing point source category for the purpose of developing information to assist the Agency in establishing effluemt limitations guidelines and standards to implement Sections 301, 304, 306, and 307 of the Federal Water Pollution Control Act Amendments of 1972.

The portions of the industry studied included the insulation board manufacturing, particleboard manufacturing, sawmills and planing mills, wet storage, i.e., pond and wet deck storage of unprocessed wood, and the operations of log washing, finishing, fabrication, by-product utilization and dry deck storage.

The wet storage, sawmills, particleboard and insulation board segment of the timber products processing industry is divided into seven subcategories. The subcategorization was based on the processing procedures involved and the water requirements, in terms of both quantity and quality.

The subcategories, as presented in this document are: wet storage, log washing, sawmills and planing mills, finishing, particleboard manufacturing, insulation board manufacturing and insulation board manufacturing with steaming or hardboard production.

Best Practicable Control Technology Currently Available (BPCT), Best Available Technology Economically Achievable (BAT), and New Source Performance Standards (NSPS) for five subcategories in this segment of the industry is defined as no discharge of process waste waters pollutants to navigable waters. The insulation board manufacturing portion of the segment has quantitative limits on discharge. Limits on the wet storage subcategory are basically no discharge of waste water pollutants with an allowance for discharge volume related to precipitation-evaporation considerations.

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SECTION I

CONCLUSIONS

For the purpose of developing Effluent Limitations Guidelines and New Source Performance Standards, this segment of the timber products processing industry has been divided into seven subcategories as follows:

(1) wet storage; (2) log washing; (3) sawmills and planing mills; (4) finishing; (5) particleboard; (6) insulation board manufacturing; and (7) insulation board manufacturing with steaming or hardboard production.

The main criterion for subcategorization was process variation. Factors such as plant size, age, nature of raw materials were considered and found not to be significant in the subcategorization as presented.

Waste water pollutants of significance for this segment of the timber products processing industry include: BOD, COD, phenols, oil and grease, pH, temperature, dissolved solids, suspended solids, color, phosphorus, and nitrogen.

In addition, in those operations employing preservatives or finishing, the following pollutants may be present.

Copper
Chromium
Arsenic
Zinc
Fluoride
Ammonia
Mercury

It was determined that for the wet storage of logs (i.e., the storage of wood raw material in self contained bodies of water; pond storage, and the storage of wood material on land, where water is sprayed on the wood), best practicable control technology (BPCT) and best available technology (BAT) limits the allowable volume of discharge to the volume of precipitation that falls on the drainage area of the wet storage facility less the natural evaporation that occurs during the months of May through October. Discharge volume during the months November through April is limited to a volume equal to the precipitation that falls on the facility. New source performance standards (NSPS) for wet decking is the same as BPCT and BAT. NSPS for pond storage is no discharge of waste water pollutants to navigable waters. For the log washing subcategory, sawmills subcategory, the finishing subcategory, and the particleboard subcategory BPCT, BAT and NSPS limitations are no discharge of water water pollutants to navigable waters. BPCT and NSPS for the insulation board manufacturing subcategories is based on the application of biological treatment before discharge, BAT for the insulation board subcategories is based on recycling a portion of the treated waste water into the process water system.

As part of the development program for effluent guidelines and standards for the timber products processing industry, other activities in the industry were investigated. These activities were the transportation and storage of logs on rivers, estuaries, and impoundments; the storage of fractionalized wood in piles; dry decking of logs, and the storage of processed timber products; and storm water runoff from storage yards. This investigation resulted in the conclusion that management techniques are available to reduce the impact on the water environment from these operations. However, the amounts, type, and quality of the information currently available is not considered adequate to serve as a basis for proposing national standards and limitations.

Because of the complexity of the Phase II timber products processing industry, and the undefinable number of processing operations, it is not possible to estimate the total industry cost of achieving the BPCTCA and BATEA. However, it is felt that the technology developed herein is practical and that the total industry cost will not be excessive. In most cases, the costs of achieving these proposed limitations can be incorporated into the selling price.

SECTION II

RECOMMENDATIONS

The recommended effluent limitations guidelines and standards are based on (1) best practicable control technology currently available, (2) best available technology economically achievable, and (3) performance standards for new sources. The effluent limitations as set forth herein are developed in depth in the following sections of this document.

RECOMMENDED EFFLUENT LIMITATIONS BASED ON BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

SUBCATEGORY	EFFLUENT LIMITATIONS
Wet Storage	A. No discharge of process waste water pollutants between May 1 and October 31, except a volume of water equal to the difference between the mean precipitation for a given month and 10% of the annual lake evaporation.
	B. No discharge of process waste water pollutants between November 1 and April 30, except a volume of water equal to the mean precipitation that falls on the drainage area of the wet storage facility.
	C. When a discharge is allowed the following limitations shall apply:

	Daily Maximum	30-Day Average
(metric units)	maximum diameter, cm	
Debris	2.54	2.54
pH	Within the range 5.5 to 9.0	
(english units)	maximum diameter, in	
Debris	1.0	1.0
pH	Within the range 5.5 to 9.0	

Log Washing	No discharge of process waste water pollutants to navigable waters
Sawmills and planing mills	No discharge of process waste water pollutants to navigable waters
Finishing	No discharge of process waste water pollutants to navigable waters

Particleboard	No discharge of process waste water pollutants to navigable waters	

Insulation board	Daily Maximum kg/kkg (lb/ton)	30-Day Average kg/kkg (lb/ton)
BOD_5	3.75 (7.50)	1.25 (2.50)
TSS	9.40 (18.80)	3.13 (6.25)
pH	Within the range 6.0 to 9.0	

Insulation board manufacturing with steaming or hardboard production	Daily Maximum kg/kkg (lb/ton)	30-Day Average kg/kkg (lb/ton)
BOD_5	11.3 (22.60)	3.75 (7.50)
TSS	9.40 (18.80)	3.13 (6.25)
pH	Within the range 6.0 to 9.0	

RECOMMENDED EFFLUENT LIMITATIONS BASED ON BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

SUBCATEGORY	EFFLUENT LIMITATIONS
Wet Storage	A. No discharge of process waste water pollutants between May 1 and October 31, except a volume of water equal to the difference between the mean precipitation for a given month and 10% of the annual lake evaporation.
	B. No discharge of process waste water pollutants between November 1 and April 30, except a volume of water equal to the mean precipitation that falls on the drainage area of the wet storage facility.
	C. When a discharge is allowed the following limitations shall apply:

	Daily Maximum	30-Day Average
(metric units)	maximum diameter, cm	

Debris	2.54	2.54
pH	Within the range 5.5 to 9.0	
(english units)	maximum diameter, in	
Debris	1.0	1.0
pH	Within the range 5.5 to 9.0	

Log Washing	No discharge of process waste water pollutants to navigable waters
Sawmills and planing mills	No discharge of process waste water pollutants to navigable waters
Finishing	No discharge of process waste water pollutants to navigable waters
Particleboard	No discharge of process waste water pollutants to navigable waters

Insulation board	Daily Maximum kg/kkg (lb/ton)	30-Day Average kg/kkg (lb/ton)
BOD5	1.13 (2.25)	0.38 (0.75)
TSS	2.85 (5.70)	0.85 (1.90)
pH	Within the range 6.0 to 9.0	

Insulation board manufacturing with steaming or hardboard production	Daily Maximum kg/kkg (lb/ton)	30-Day Average kg/kkg (lb/ton)
BOD5	3.38 (6.75)	1.13 (2.35)
TSS	2.85 (5.70)	0.85 (1.90)
pH	Within the range 6.0 to 9.0	

RECOMMENDED NEW SOURCE PERFORMANCE STANDARDS

SUBCATEGORY	EFFLUENT LIMITATIONS
Wet Storage	A. Subject to the provisions of paragraphs B and C, which are applicable only to

wet decking operations, there shall be no discharge of process waste water pollutants to navigable waters.

B. No discharge of waste water pollutants between May 1, and October 31, except a volume of water equal to the difference between the mean precipitation for a given month and 10% of the annual lake evaporation.

C. No discharge of waste water pollutants between November 1 and April 30, except a volume of water equal to the mean precipitation that falls within the drainage area of the wet storage facility.

D. When a discharge is allowed the following limitations shall apply:

	Daily Maximum	30-Day Average
(metric units)	maximum diameter, cm	
Debris	2.54	2.54
pH	Within the range 5.5 to 9.0	
(english units)	maximum diameter, in	
Debris	1.0	1.0
pH	Within the range 5.5 to 9.0	

Log Washing	No discharge of process waste water pollutants to navigable waters
Sawmills and planing mills	No discharge of process waste water pollutants to navigable waters
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pH	Within the range 6.0 to 9.0	

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BOD_5	11.3 (22.60)	3.75 (7.50)
TSS	9.40 (18.80)	3.13 (6.25)
pH	Within the range 6.0 to 9.0	

SECTION III

INTRODUCTION

PURPOSE AND AUTHORITY

Section 301(b) of the Federal Water Pollution Control Act, as amended, hereinafter cited as "The Act," requires the achievement be not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best practicable control technology currently available as defined by the Administrator pursuant to Section 304(b) of the Act. Section 301(b) also requires the achievement be not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best available technology economically achievable which will result in reasonable further progress towards the national goal of eliminating the discharge of all pollutants, and which reflect the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the best available demonstrated control technology, and processes, operating methods, or other alternatives, including where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction practices achievable including treatment techniques, process and procedure innovations, operation methods, and other alternatives. The regulations proposed herein set forth effluent limitation guidelines pursuant to Section 304(b) of the Act for selected segments of the timber products processing category.

Section 306 of the Act requires the Administrator, after a category of sources is included in a list published pursuant to Section 306(b)(1)(A) of the Act, to propose regulations establishing Federal standards of performances for new sources within such categories. The Administrator published in the Federal Register of January 16, 1973, (38 F.R. 1624), a list of 27 source categories. Publication of the list constituted announcement of the Administrator's intention of establishing, under Section 306, standards of performance applicable to new sources with in the timber products processing category of sources.

BASIS FOR GUIDELINES AND STANDARDS DEVELOPMENT

The effluent limitations and standards of performance recommended in this document were developed in the following manner:

1. An exhaustive review of available literature was conducted. This included researches at the University of Florida, University of California, Stanford University, Oregon State University, University of Washington, and University of North Carolina. Additional literature searches were conducted at the United Nations Library in New York, N.Y. and the Forest Products Laboratory in Madison, Wisconsin.

2. Questionnaires were submitted to individual particleboard and insulation board plants by the National Particleboard Association and The Acoustical and Insulating Materials Association, respectively. Seventy particleboard plants responded, twenty five particleboard responses were usable, and this information was incorporated into the data base. Samples of the questionnaires are shown in Appendix A.

3. On-site inspections and sampling programs were conducted at numerous installations throughout the U. S. Information obtained included process diagrams, water usage, water management practices, waste water characteristics, and control and treatment practices information.

4. Other sources of information included: personal and telephone interviews; meetings with industry advisory committees, consultants, and EPA personnel; State and Federal permit applications; and internal data supplied by the industry.

The reviews, analyses, and evaluations were coordinated and applied to the following:

1. An identification of pertinent features that could potentially provide a basis for subcategorization of the industry. These features included the nature of raw materials utilized, plant size and age, the nature of processes, and others as discussed in Section IV of this report.

2. A determination of the water usage and waste water characterization for each subcategory, as discussed in Section V, including the volume of water used, the sources of pollutants, and the types and quantities of constituents in the waste waters.

3. An identification of the waste water constituents, as discussed in Section VI, which are characteristic and which were determined to be pollutants subject to effluent limitation guidelines and standards.

4. An identification of the control and treatment technologies presently employed or capable of being employed by the industry, as discussed in Section VII, including the effluent level obtainable and treatment efficiency and reliability associated with each technology.

5. An evaluation of the cost, energy, and non-water quality aspects associated with the application of each control and treatment technology as discussed in Section VIII.

DEFINITION OF THE TIMBER PRODUCTS INDUSTRY

The timber products industry is defined in this study as that listed in Standard Industrial Classification (SIC) Major Group 24. The major portions included in SIC 24 are:

1. Logging camps and logging contractors; 2. Sawmills and planing mills; 3. Millwork, veneer, plywood and structural wood members; 4. Wood containers; 5. Wood buildings and mobile homes; and 6. Miscellaneous wood products.

Segregated under the various major topics in Major Group 24 are hundreds of industrial operations with products ranging from finished lumber, hardboard, and mobile homes to tobacco hogshead stock, chicken coops, and toothpicks. The magnitude and complexities of operations range from backyard wood carving, to complexes covering 1000 acres or more.

Also, rather than each operation being a discrete function within the industrial segment, the timber products processing industry is an interrelated one. As illustrated in Figure 1, the waste material from one operation is often a raw material for another. An example of this is in the production of particleboard where sawdust, planer shavings, veneer cores, plywood scraps, and other waste wood materials commonly serve as raw materials.

Earlier, effluent guidelines and standards were developed for the barking, veneer, plywood, hardboard, and wood preserving segment of the timber products processing industry. These operations were considered to be the most significant sources of water pollution problems. Guidelines and standards for that segment of the industry were promulgated on April 18, 1974 (F.R. 39, 13942). In order to achieve an orderly, logical, and practical approach to the development of effluent guidelines, the remaining portions of the industry have been considered in three broad areas: (1) raw material and waste product storage and handling, (2) sawmills, and planing mills, and various unit operations, and (3) the production of insulation board and particleboard. The first area includes such operations as timber transport and storage; storage piles of fractionalized wood; and runoff from roofs, yards, and other sources. Timber harvesting may be further defined as all operations concerned with the cutting and trimming of trees in the forest. Timber transport involves the moving of logs from the harvest area by means of water, rail, or truck to a processing plant. Log storage includes both storage in water and on land, whether at a processing plant site or at other areas. Storm runoff is defined as all water produced by precipitation falling on the roof of a facility or on the adjacent grounds. Storm runoff is considered to be separate from process waters and

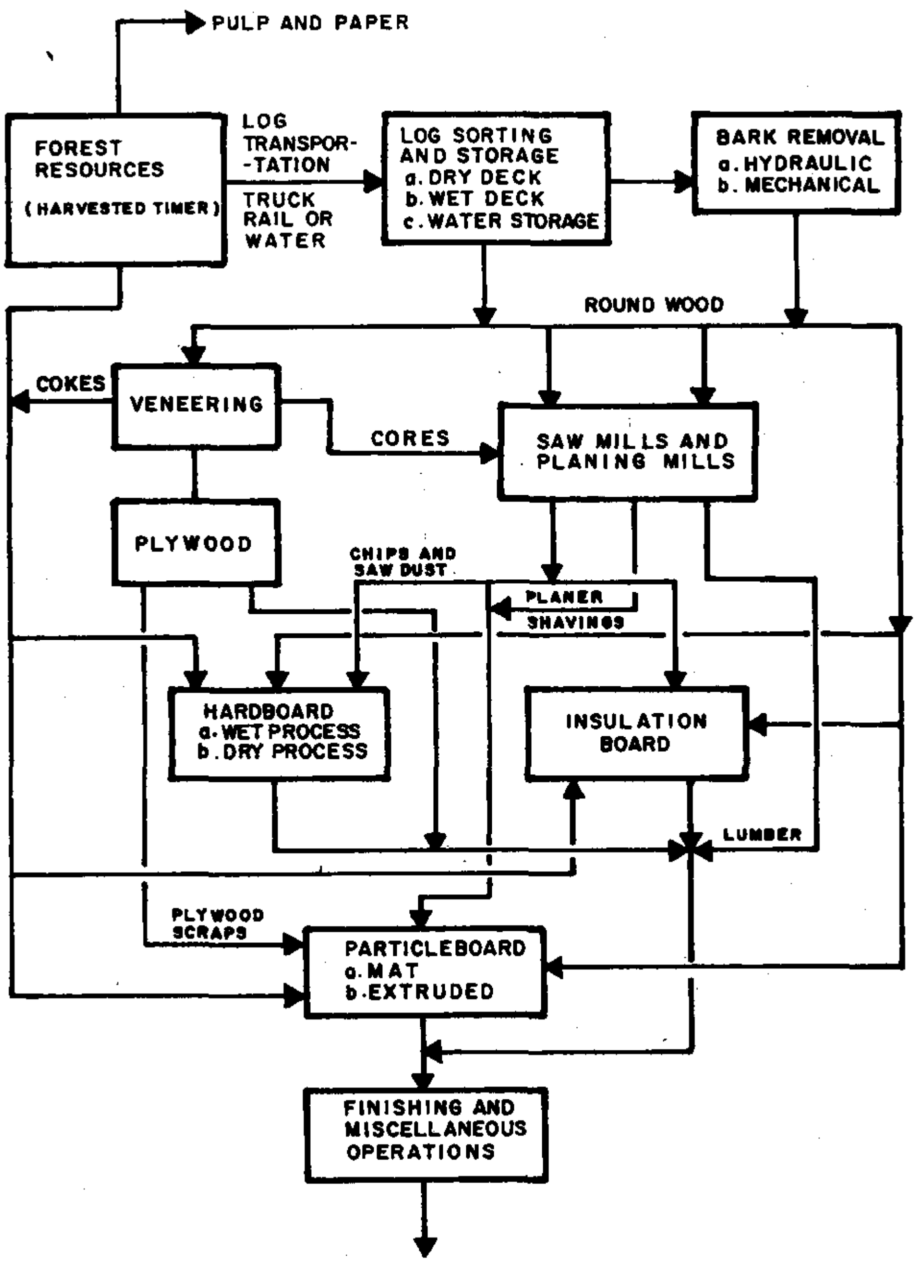


FIGURE 1 INTERRELATIONSHIPS OF THE TIMBER PRODUCTS INDUSTRY

does not include runoff originating in storage piles of logs or fractionalized wood.

In the second study area sawmills and planing mills are considered to be those installations producing lumber and similar products from logs. Other unit processes include log washing, fabricating, finishing, machining and by-product utilization. These operations may occur either singularly or in combination with one another or with other processes. Log washing removes grit from logs by washing the logs with water. Fabricating includes those operations using adhesives to join various wood members. Finishing, such as sanding, varnishing or painting, concludes the final processing activites. Machining shapes wood or wood products to a desired form by splitting, turning, carving, drilling, sawing, grooving, and cutting. By-product utilization converts bark, sawdust, and other scrap material into wood flour, pressed logs, mulch, ornamental bark, or molded wood. This does not include, however, the production of insulation board or particleboard.

Insulation board is a form of fiberboard, which in turn is a broad generic term applied to sheet materials constructed from ligno-cellulosic fibers. It can perhaps best be classified on the basis of density, and most broadly as "compressed" and "noncompressed." Compressed fiberboards (hardboards) have a density over 0.5 g/cu cm (31 lb/cu ft) and noncompressed fiberboards (insulation boards) have a density of less than 0.5 g/cu cm (31 lb/cu ft). Insulation boards are usually manufactured in thicknesses between 5 and 25 mm (3/8 and 1 in). On a basis of density, insulation board may be subdivided into semi-rigid insulation board and rigid insulation board with densities of 0.15 g/cu cm (9.5 lb/cu ft) and 0.15 to 0.40 g/cu cm (9.5 to 25 lb/ cu ft), respectively. Semi-rigid insulation board is normally used only for insulation purposes while rigid insulation board may be used for sheathing, interior panelling, and as a base for plaster or siding.

There are seven basic types of insulation board products as cited by the Acoustical and Insulating Materials Association. The principal types include:

1. Building board - General purpose product for interior construction.

2. Insulating roof deck - A three-in-one component which provides roof deck, insulation, and finished inside ceiling. (Insulation board sheets are laminated together with waterproof adhesives).

3. Roof insulation - Insulation board designed for flat roof decks.

4. Ceiling tile - Insulation board embossed and decorated for interior use. It also provides acoustical qualities.

5. Lay-in-panels - A tile used for suspended ceilings.

6. Sheathings - Board used extensively in construction because of its insulative, bracing strength, and noise control qualities.

7. Sound deadening insulation board - A product designed specifically for use in buildings to control noise level.

The American Society for Testing and Materials sets standard specifications for the above categories and others.

Particleboards are board products which differ from conventional fiber boards in that they are composed of distinct particles of wood or other ligno-cellulosic materials which are bonded together with an organic binder. The "particles" vary is size and must be distinguished from the fibers used in insulation and hardboard. Other terms used for particle board include chipboard, flakeboard, silverboard, shaving board, and wood waste board. Particleboard is a highly engineered product which can be formed to meet varied specifications. As a result of its being produced in wide density ranges, it is usually divided into categories of low density (0.25 to 0.40 g/cu cm) (15 to 25 lb/cu ft), medium density (0.40 to 0.80 g/cu cm) (25 to 50 lb/cu ft), and high density (0.80 to 1.20 g/cu cm) (50 to 75 lb/cu ft).

Low density particleboards are for use either as panel material, where heat or sound insulation is important, or as a core in veneered constructions where weight savings are important. The major use for low density particleboard is as the core in wood or plastic flush doors. These boards are usually manufactured in thicknesses of no greater than 2.5 cm (1 in).

Most of the particleboard currently produced can be classified as medium density board having a density some 10 to 20 percent higher than that of the species of wood or material used. The mat-formed board may be homogeneous throughout its thickness with respect to the particles used; or it may be composed of two or more discreet layers; or it may be graduated from face to core with respect to particle size. Extruded particlebaord, however, must use the same type of particle throughout its thickness because of the nature of its production.

High density particleboard is quite similar to hardboard in density, appearance, and application, the basic difference being one of bond. It is usually produced in the same thicknesses as conventional hardboard, and the small sized particles which are used may approach wood fiber in size.

The U. S. Department of Commerce sets forth a Commercial Standard for manufacture of mat-formed wood particleboard, which covers both interior and exterior applications and includes such property requirements as density, modulus of elasticity, modulus

TABLE 1.

PROPERTY REQUIREMENTS OF MAT FORMED PARTICLEBOARD

Type	Density (Grade) (min. avg.)	Class	Modulus of Rupture (min. avg.) ATM	Modulus of Elasticity (min. avg.) ATM	Internal Bond (min. avg.) ATM	Linear Expansion (max. avg.) percent	Screw Holding (min. avg.) Face Kg	Edge Kg
1	A	1	164	23,820	15	0.55	204	-
	(High Density 0.80 gm/cm3 and over)	2	232	23,820	11	0.55	-	-
1	B	1	110	17,010	6	0.35	102	73
	(Medium Density between 0.40 and 0.80 gm/cm3)	2	164	27,220	5	0.30	120	91
1	C	1	55	10,210	2	0.30	57	-
	(Low Density 0.40 gm/cm3 and under)	2	96	17,010	3	0.30	80	-
2	A	1	164	23,820	10	0.55	204	-
	(High Density 0.80 gm/cm3 and over	2	232	34,030	28	0.55	227	159
2	B	1	124	17,010	5	0.35	102	73
	(Medium Density less than 0.80 gm/cm3)	2	171	30,620	5	0.25	114	91

Type 1 - Mat formed particleboard (generally made with urea-formaldehyde resin binders) suitable interior applications.

Type 2 - Mat-formed particleboard made with durable and highly moisture and heat resistant binders (generally phenolic resins) suitable for interior and certain exterior applications.

of rupture, internal bond, screw holding, and linear expansion (Table 1).

BACKGROUND OF THE TIMBER PRODUCTS INDUSTRY

Forests have from the beginning been one of North America's more important natural resources. The earliest sawmills and lumbering operations date back to 17th century New England. The apparently inexhaustable supply of virgin timber met the needs of a developing country as the lumbering frontier spread to the Middle Atlantic and Lake States and onward to the South and the Pacific Northwest. By the early 20th century the industry was well established throughout the country and continuing development of equipment and techniques increased productivity. There are currently in the United States over 200 million commercial ha (500 million ac) of forest and over 40,000 establishments in the timber products processing industry.

In recent years, the U. S. has become an increasingly important exporter of wood products. However, since the U. S. has the world's highest per capita consumption of forest products, imports usually double exports, with Canada being the largest supplier. Pressing housing needs for domestic and foreign markets have created shortages in lumber supply and have raised questions concerning export control. Nevertheless, foreign trade affords increased incentives for production.

The economics of the timber products industry is increasingly affected by growth as well as changes in product demand. Over the past half century an awareness of the losses in timber supply associated with processing has developed and from this has stemmed an extensive waste utilization program, i.e., the use of chips, shavings, sawdust, and other scraps in the production of various wood based products. Insulation board alone is produced in ten types, each meeting specific needs of the market and creating new demands. Since 1956, according to the U. S. Department of Agriculture, 64 percent of the growth in the insulation board industry has been in new plants as opposed to expansion of existing facilities. Within the last decade, the industry has more than doubled its capacity, as shown in Figure 2. The increased capacity has been accompanied by a decrease in use of non-wood fibers in production as indicated by a 4.8 percent increase per year in raw wood materials consumed for the period 1956 to 1964.

One of the newest additions to the industry, particleboard, has experienced an eight-fold growth in production since 1956 (Figure 3) because of its versatility. The industry has also expanded into the production of prefinished panels, wood containers, prefabricated buildings, and specialty products. In 1958, the production of particleboard was over 1.16 million sq m (125 million sq ft) on a 1.91 cm (0.75 in) basis) (5). Production rates has tripled this figure by 1962, and in 1972 the Bureau of Census reported a production peak of over 300 million sq m (three

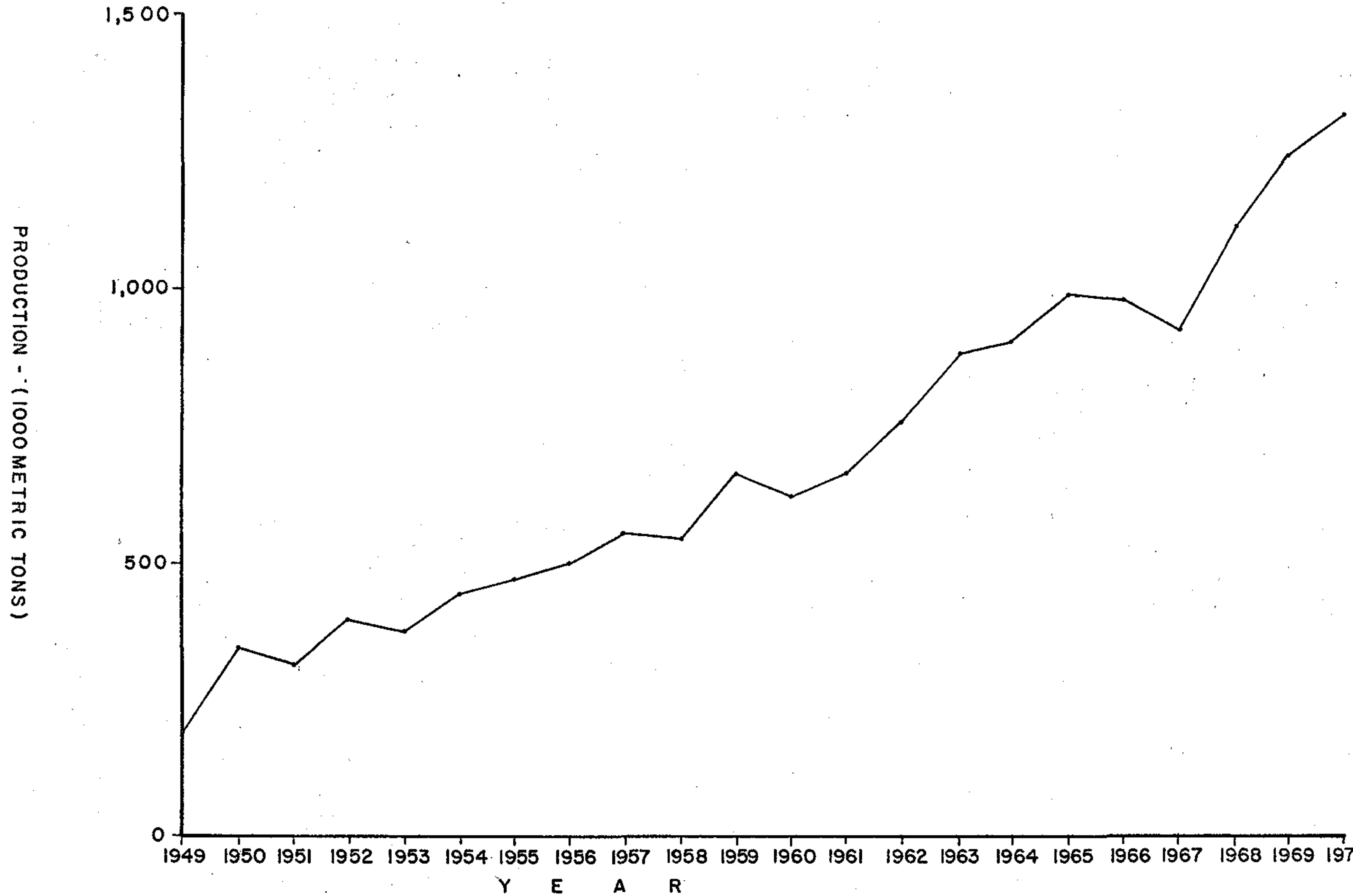


FIGURE 2 PRODUCTION OF INSULATION BOARD, 1949-1970

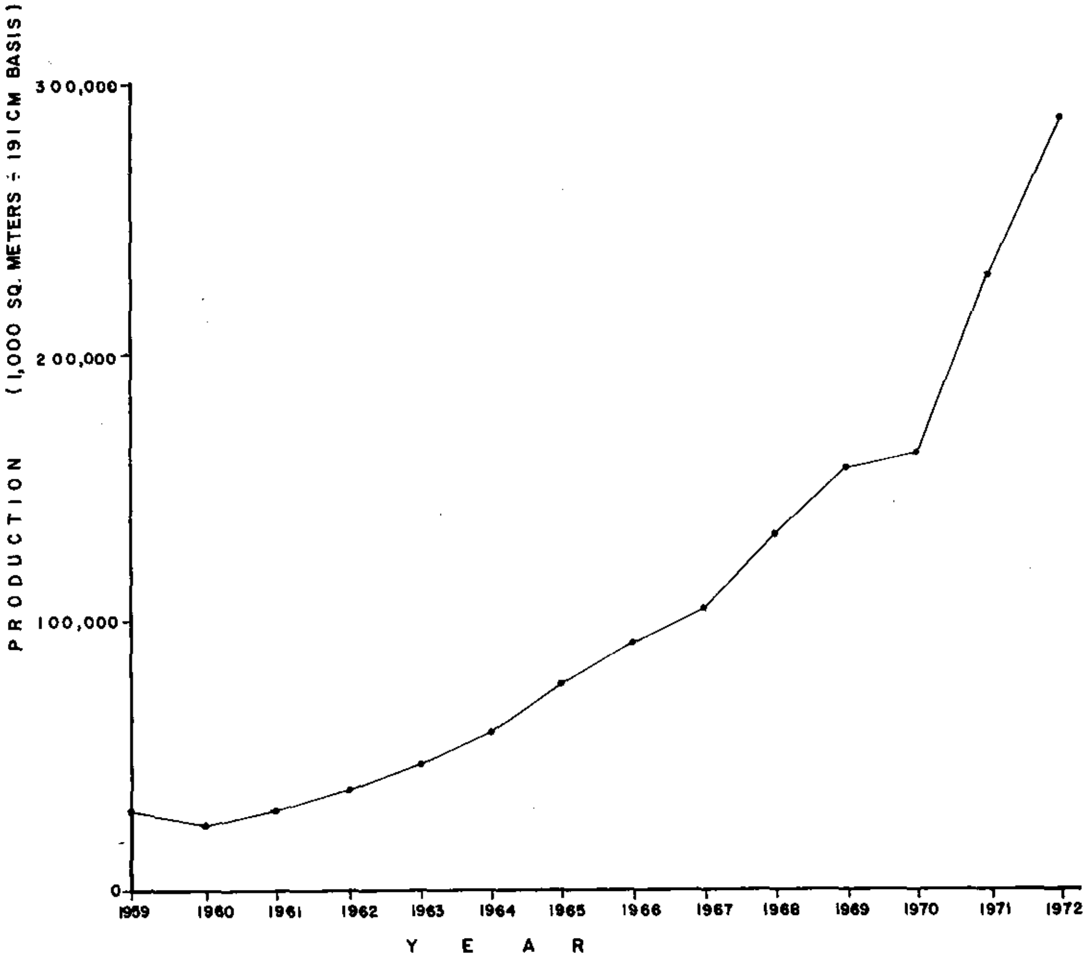


FIGURE 3 PARTICLEBOARD PRODUCTION

billion sq ft) on a 1.9 cm (0.75 in) basis from 71 plants. This is illustrated in Figure 2.

A study by the U. S. Department of Agriculture on industry trends of particleboard during the period 1956 to 1966, reported only 25 particleboard plants in the U.S. in 1956. The current number of approximately 76 particleboard plants indicates a growth rate of 200 percent in the 17 year period. During the period from 1956 to 1966 three-fourths of increased particleboard capacity was contributed to new mills which had the greatest development in the South and West. Prior to 1961, production output was between 48 and 63 percent of designed plant capacity; but since 1961, the percentage has increased to 70 percent capacity, except in the North where output is about 50 percent of capacity.

INVENTORY OF THE TIMBER PRODUCTS INDUSTRY

The U. S. possesses 200 million ha (0.5 billion ac) of commercial forest land with a total inventory of 6 billion cu m (2,400 billion bd ft). This land is owned by four groups as indicated in Table 2.

The major single user of forest resources is the pulp and paper industry which produces about 47 billion metric tons (52 billion tons) of pulp per year and requires approximately 50 million cords of wood. This corresponds to approximately 126 million cu m (4.5 billion cu ft) of timber per year. In 1968, the plywood industry produced about 1.4 billion sq m (15 billion sq ft) of 9.53 mm (3/8 in) softwood plywood and 0.198 billion sq m (2.13 billion sq ft) of 6.35 mm (0.25 in) hardwood plywood. This corresponds to approximately 30 million cu m (1 billion cu ft) of timber in 1968. In 1973, the total volume of timber utilized by the plywood industry was about 56 million cu m (2 billion cu ft). The production of hardwood plywood requires an additional 28 million cu m (1 billion cu ft) of timber. The total timber production in 1972 was about 88 thousand cu m (38 million bd ft). This corresponds to about 112 million cu m (4 billion cu ft) of timber per year. The sum of these uses 322 million cu m (11.5 billion cu ft) compared with the reported total timber removal of 392 million cu m (14 billion cu ft) in 1970.

Following harvesting, timber must be transported to and stored in various stages to processing plants. The storage and transporation of logs in water is practiced extensively in the northwestern U. S. and in Alaska. In 1964, approximately 9,000 ha (23,000 ac) of water were used to store and transport logs in the Northwest. This was comprised of about 6,000 ha (14,000 ac) in Oregon, 2,000, ha (4,000 ac) in Washington, 2,000 ha (4,000 ac) in California, and 400 ha (1,000 ac) in Idaho. It is estimated that as of 1971 Alaska used about 400 ha (1,000 ac) of its waterways for logs storage and transportation. Logs are transported almost exclusively by water in Alaska.

In contrast, virtually all raw material transport in the South and East is by truck or by rail, where logs may be hauled either

TABLE 2

AREA AND VOLUME STATISTICS BY OWNERSHIP CLASSES, 1970

Ownership Classes	Commercial Area Held (Million Hectares)	In Million Cubic Meters					
		Total Softwood Sawtimber Volume			Total Hardwood Sawtimber Volume		
		Inventory	Growth	Removals	Inventory	Growth	Removals
National Forests	37.2	2,291	20	30	91	3	1
Other Public	17.9	520	9	10	93	4	1
Forest Industry	27.3	742	23	38	159	6	4
Other Private	119.9	891	41	33	859	33	28
National Total	202.3	4,444	93	111	1,202	46	34

in tree length, logs in cord pile lengths, or in a chipped form. No water storage of logs is practiced in the southern U. S. primarily because southern pine tends to sink. In a study of land decking by the Southern Forest Products Association, 48 plants responded to questionnaires out of a total of 79 that were sent. Of the companies responding, 21 companies used spray on the land decks and 27 did not. The only case of water transportation of logs observed in the South involved logs being harvested from an island in the Mississippi River. In this special case, it was easier to barge the logs down the river to the mill site than to barge them to the adjacent bank of the river for transfer to truck or rail.

The most complete available inventory of sawmills is contained in the 1973 Directory of Forest Products Industry. This reference should be consulted for information on individual mills. In order to present a general perspective on the magnitude and distribution of sawmills in the U.S. Figures 4 and 5 respectively, indicate the number of sawmills in 1967 by state and region, and a breakdown of production in millions of bd ft on a state, regional, and national basis as well as by major type shown, i.e., hardwood or softwood. The total number of sawmills and planing mills in 1967 was 10,271. It should be noted that the figures presented in Table 3 are for general sawmills and planing mills. These are defined by the Bureau of Census as those establishments primarily engaged in sawing rough lumber and timber, from logs and bolts; resawing cants and flitches into lumber, including box lumber and softwood cutstock; planing mills combined with sawmills; and separately operated planing mills. Thus, the segment of the industry which produces hardwood dimension, flooring, and special product sawmills (totaling 1,190 establishments in 1967) is not included. Also not included are mills producing prefinished panels, millwork, wood containers, prefabricated wood products, and other miscellaneous wood products. These will be covered in other sections of this document.

Table 3, from Forest Industries, Volume 99 indicates the range of mill sizes. The information presented is a result of a survey of mills responsible for approximately 65.2 percent of the total 1971 production in the U. S.. It should be noted that a relatively small number of mills represent an extremely large percentage of production. Thus, in the western region, 257 mills, less than three percent of the total, accounted for nearly 37 percent of the total production in the U.S. The top twenty-five companies in the U. S. accounted for approximately 30 percent of the total production of the country in 1971.

Those unit operations encountered at sawmills which may result in significant waste water problems include storage, washing, and debarking (Barking standards were promulgated earlier (40 CFR Part 429, Subpart A)) of logs. The following discussion of log washing is presented in order that an indication may be provided of its present magnitude and frequency of occurrence as well as possible future trends in the industry.

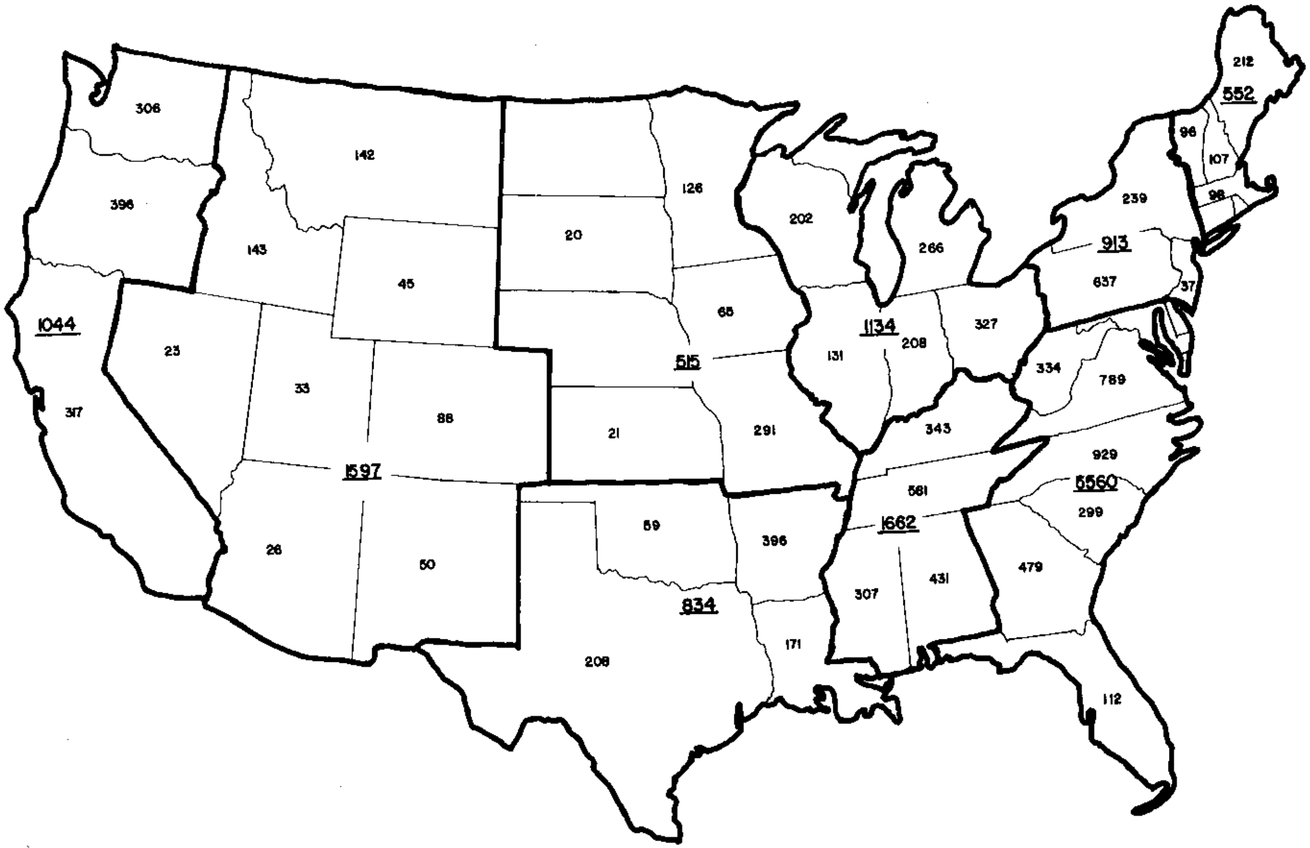


FIGURE 4 SAWMILLS AND PLANING MILLS

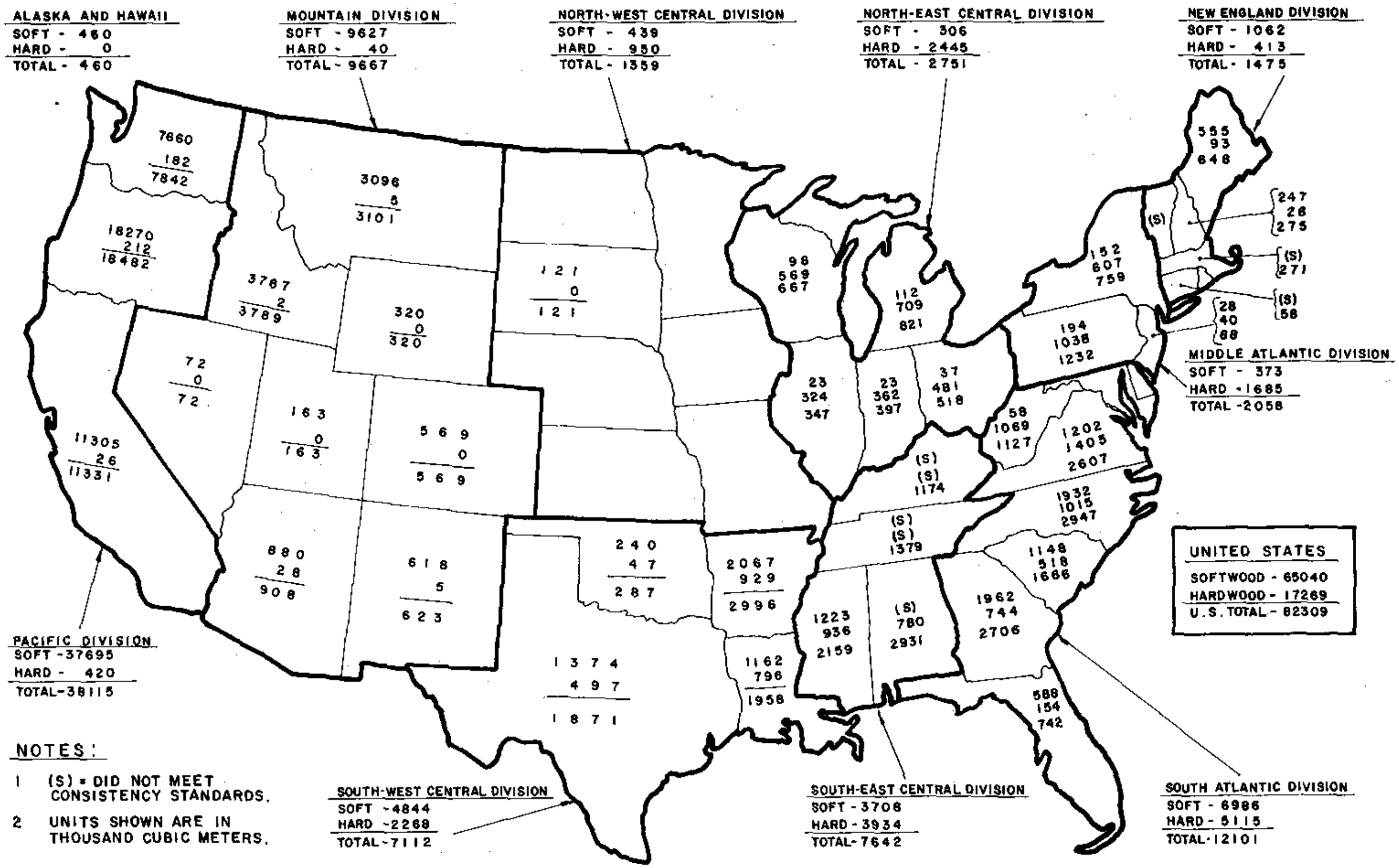


FIGURE 5 PRODUCTION OF SOFTWOODS AND HARDWOODS 1967

TABLE 3

LUMBER PRODUCTION BY REGIONS - 1971 AND BY MILL SIZE*

Region	Production Range (Thousand Cubic Meters)	Number Companies	Number Mills	Production (Meters)
West	120 - up	87	257	33,038,519
	60 - 120	55	59	4,567,041
	23 - 60	96	106	3,613,833
	12 - 23	36	40	576,399
	7 - 12	16	16	132,514
	Other	83	84	166,189
	Totals	373	562	42,094,495
South	120 - up	19	71	5,847,699
	60 - 120	16	25	1,246,298
	23 - 60	63	68	2,120,136
	12 - 23	83	88	1,309,708
	7 - 12	58	58	491,542
	Other			
	Totals	364	439	11,354,608
North and East	120 - up	-	-	--
	60 - 120	4	7	306,152
	23 - 60	17	32	640,873
	12 - 23	32	39	470,201
	7 - 12	50	52	415,362
	Other	162	162	477,557

*The above production represents approximately 65.2 percent of total U.S. production for 1971.

Log washing is one of several unit operations which may or may not be associated with a particular sawmill. While numerical inventory of those plant practicing log washing is not available, it can be stated that the majority of sawmills do not practice log washing. A survey of southern pine mills by one industry association showed that approximately twelve percent of the mills returning questionnaires utilized log washing. Plant visits and information developed during the current guidelines development program determined that of the several dozen mills observed throughout the Southeast, Northwest, and Northeast, only a few were found to have log washing operations.

The millwork industry comprises establishments primarily engaged in manufacturing fabricated millwork, either prefinished or unfinished. The number of mills and their distribution in 1967 is presented in Figure 6. It should be noted that the values for number of mills include planing mills only if such mills are primarily engaged in millwork production. For information regarding specific companies or mills, reference should be made to Sweats Catalogue or any other such manufacturer's guide. Inventories are also available through the associations listed in Appendix B.

In 1967 the total number of establishments involved in the production of prefabricated structural wood members and wood laminates was 43. While no current complete inventory is available, it can be assumed that the magnitude of the industry has not varied significantly since 1967. The American Institute of Timber Construction has provided the inventory of its member companies presented in Table 4. This inventory includes the majority of the industry both in number of plants and in production.

The wood container segment of the timber products industry includes establishments manufacturing nailed wooden boxes, wirebound boxes and crates, veneer and plywood containers, and cooperage. Figure 7 gives the total number of such establishments and their distribution by region and state for 1967.

Because of changes in the Standard Industrial Classification (SIC) Codes, an accurate inventory of establishments involved in the manufacturing of wood buildings and mobile homes is not available. There were, however, about 500 establishments operated by over 330 firms engaged in the manufacture of mobile homes. The total production of mobile homes in the U. S. in 1972 was approximately 567,000 units according to the Mobile Homes Manufacturers' Association.

Another important product of the timber products industry are prefinished panels. A wide variety of factory finishing operations are performed, to some degree, on most all types of flat-stock, wood panels including hardwood and softwood plywood, hardboard, and particle board panels. Figure 8 shows the distribution of panel producing plants in the U.S. which, as

TABLE 4

MANUFACTURERS OF PREFABRICATED STRUCTURAL WOOD MEMBERS AND WOOD LAMINATES

Able Fabricators, Inc.
Spokane, Washington

Anthony Forest Products Co.
El Dorado, Arkansas

Architectural Wood Products, Inc.
Fresno, California

Bohemia Wood Systems
Eugene, Oregon

Boise Cascade Corporation
Boise, Idaho

Ronald A. Coco, Inc.
Baton Rouge, Louisiana

Duco-Lam, Inc.
Drain, Oregon

El Dorado Laminated Beams, Inc.
El Dorado Springs, Missouri

The Intermountain Company
Salmon, Idaho

Koppers Company, Inc.
Pittsburgh, Pennsylvania
Plant Locations:
Magnolia, Arkansas
Morrisville, North Carolina
Sumner, Washington

Laminated Timbers, Inc.
London, Kentucky

Laminated Wood Products Co.
Ontario, Oregon

Mid-West Lumber Company
Lincoln, Nebraska

Riddle Laminators
Riddle, Oregon

Rosboro Lumber Company
Springfield, Oregon

Standard Structures, Inc.
Santa Rosa, California

Structural Wood Systems, Inc.
Greenville, Alabama

Timberweld Manufacturing
Billings, Montana

Timfab, Incorporated
Clackamas, Oregon

Unadilla Laminated Products
Unadilla, New York

Weyerhaeuser Company
Tacoma, Washington
Plant Locations:
Albert Lea, Minnesota
Cottage Grove, Oregon

Wood Fabricators, Inc.
North Billerica, Massachusetts

Woodlam, Incorporated
Tacoma, Washington

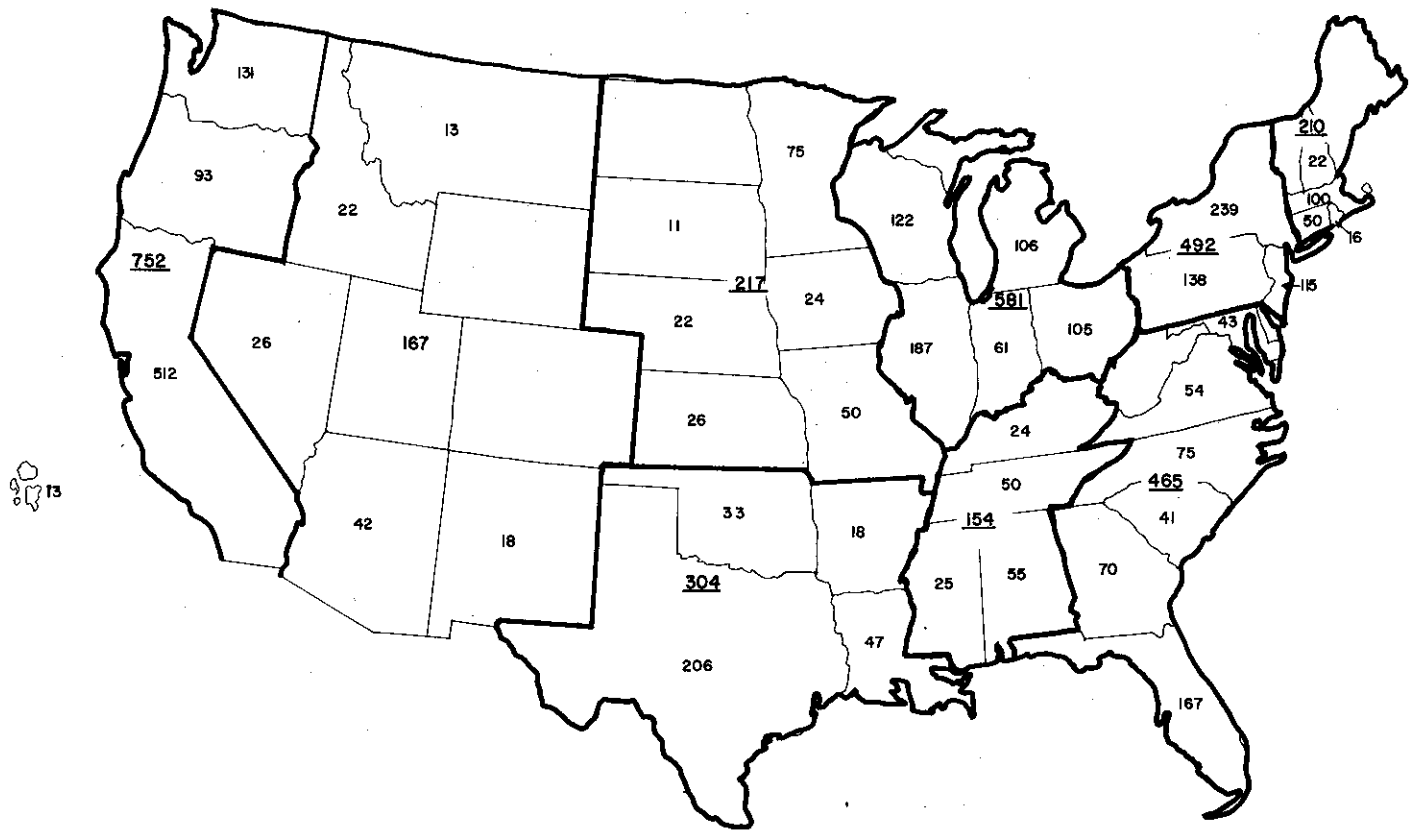


FIGURE 6 MILLWORK PLANTS

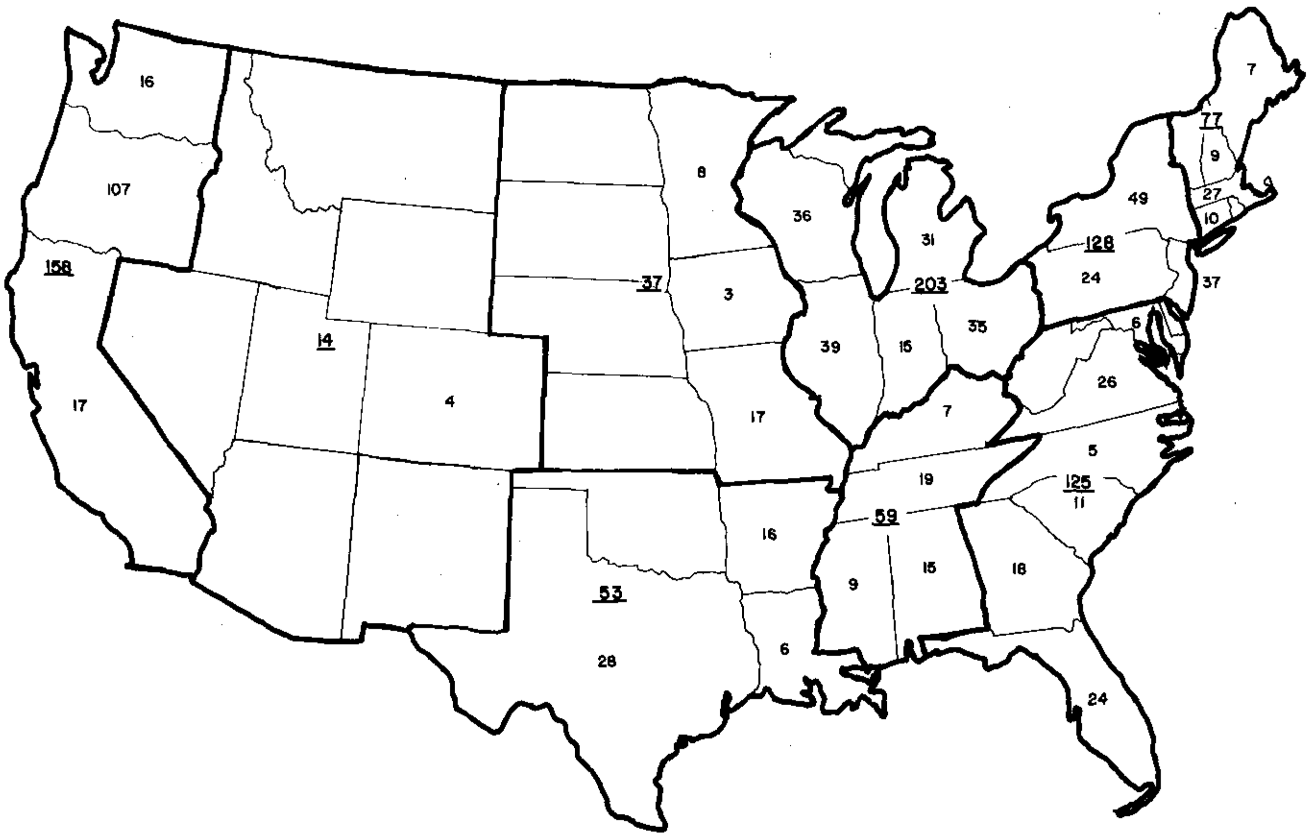


FIGURE 7 WOOD CONTAINER MANUFACTURERS

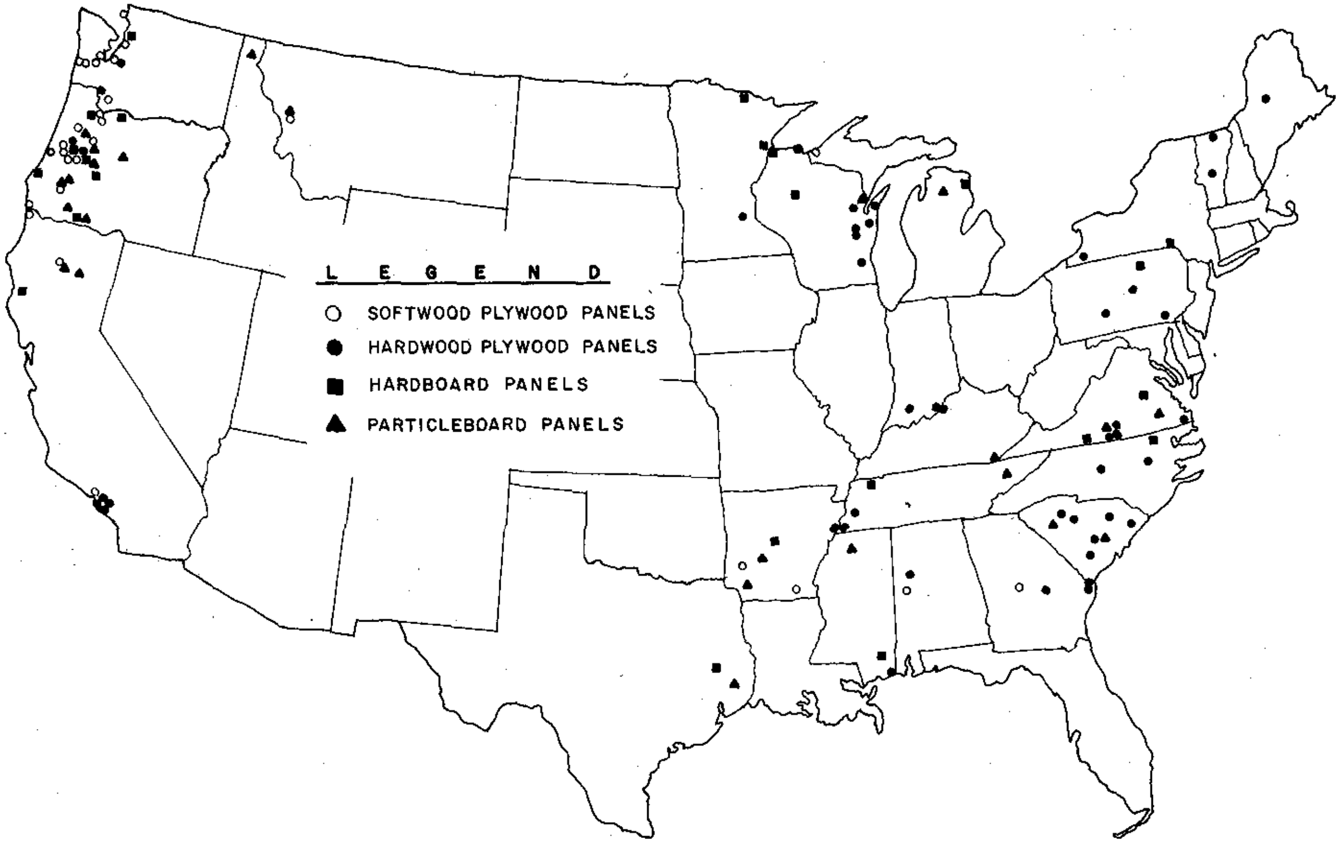


FIGURE 8 FINISHED PANEL PRODUCING PLANTS

reported by the <u>1973 Directory of the Forest Products Industry</u>, produce one or more of the types of finished panels listed in Table 5. A detailed inventory of those plants represented in Figure 8 is included in Appendix B. It should be noted that this is not intended to represent a complete inventory of this segment of the industry. In recent years rapid developments have resulted in a multitude of finishing processes with a wide variety of materials used and finished products produced. Such developments have further resulted in an ever expanding number of industrial operations being accomplished not only by the manufacturers of the basic wood products, but also by custom finishing plants not primarily associated with the timber products industry.

Another portion of the industry included in Major Group 24 comprises establishments primarily engaged in turning and shaping wood, and manufacturing various wood products such as cork and sawdust products, various carved wood novelties, and a multitude of machined and fabricated products. While an inventory of the various industries within this category is not feasible, Figure 9 gives the number of such mills and indicates their distribution by state and region.

In the U. S. there are currently 18 insulation board plants producing over 330 million sq m (3,600 million sq ft) on a 13 mm (0.5 in) basis yearly from wood or bagasse. Figure 10 categorizes these plants according to process and production. Seven of these plants also produce hardboard to varying degrees, and they all produce insulation board in either structural, mineral, or finished form. A list of the plants and their locations is given in Table 6. Of the 17 plants surveyed in this study, all produced structural insulation board, and 13 also produced finished insulation board. As for raw materials used by the plants, a majority of 12 used softwood predominantly, three used mostly hardwood, one mineral fiber, and one bagasse.

Much of the production growth of particleboard attributed to the South and West can be explained by the concentration of plants in the states of North Carolina and Oregon (Figure 11); there are 8 and 14 particleboard plants in each state, respectively, and Oregon produces one-third of the present total U.S. particleboard production (Table 7).

Of the 76 plants now producing particleboard in the U. S., 69 produce platenboard (mat-formed board) and eight produce extruded board (Table 8). The platenboard accounts for 98 percent of the total particleboard production.

<u>DESCRIPTION OF PROCESSES</u>

The following discussions of processes in the timber products industry are intended to provide a general knowledge of the operations involved in the timber industry. These descriptions are considered to be representative processes and are oriented toward their use of water and generation of waste water.

TABLE 5

TYPES OF FACTORY FINISHED PANELS

Softwood Plywood	Hardwood Plywood
Prefinished Plywood	Prefinished Parcels
Hardboard Faced	Hardboard Faced
Paper Overlaid	Paper Overlaid
Plastic Overlaid	Plastic Overlaid
Metal Overlaid	Vinyl Overlaid
Special Printed Overlaid	Special Printed Overlaid
Decorative Wall Panels	Plastic Laminated
Preprimed Plywood	Preprimed Plywood
Coated Concrete Form	

Hardboard	Particleboard
Prefinished Panels	Prefinished Panels
Factory Primed	Filled Panels
Wood Grained	Sealed Panels
Plastic Overlaid	Factory Primed
Vinyl Overlaid	Veneer Overlaid
Black-Dyed	Plastic Overlaid
	Vinyl Overlaid
	Polyester Filled and Printed

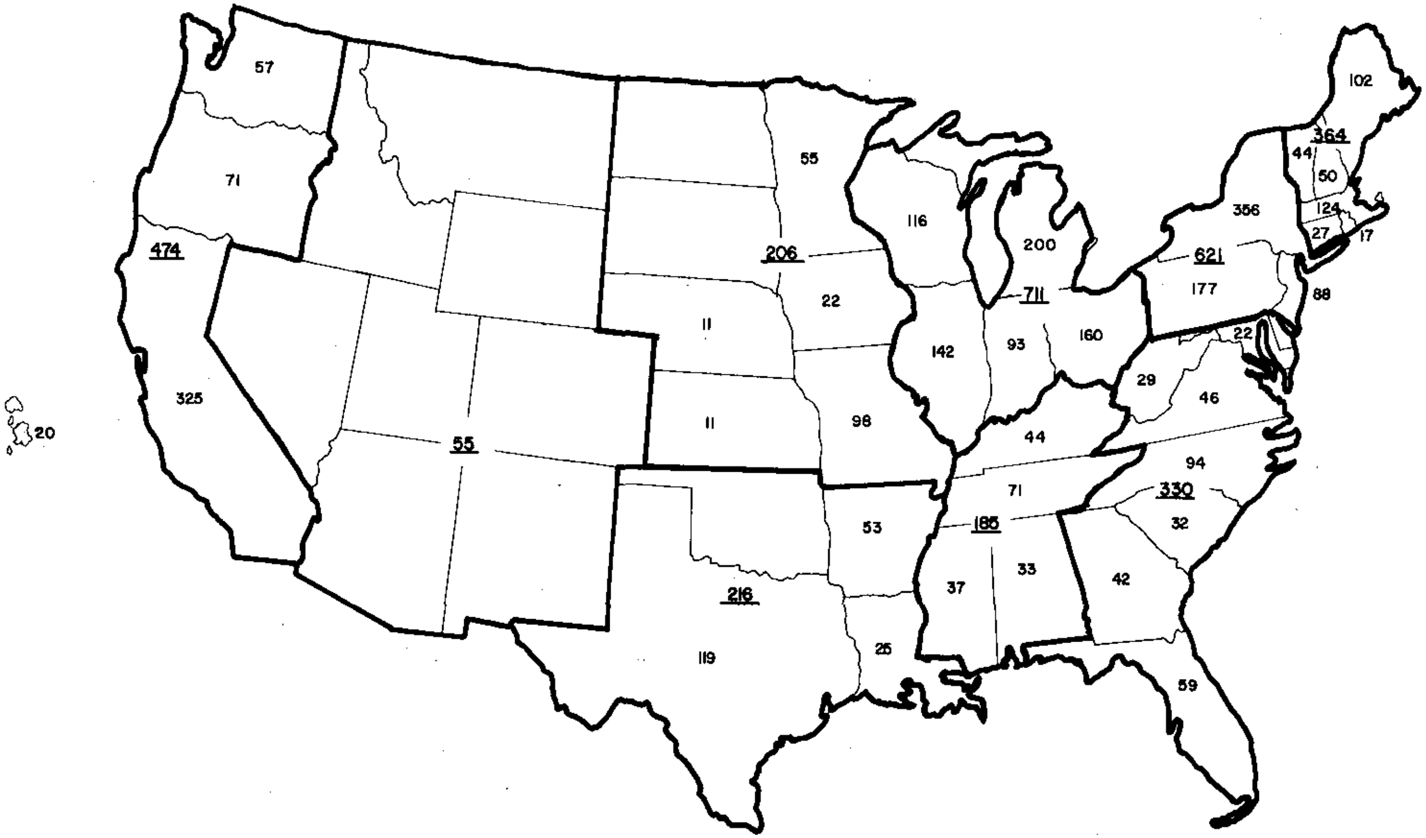


FIGURE 9 WOOD PRODUCTS NOT ELSEWHERE CLASSIFIED

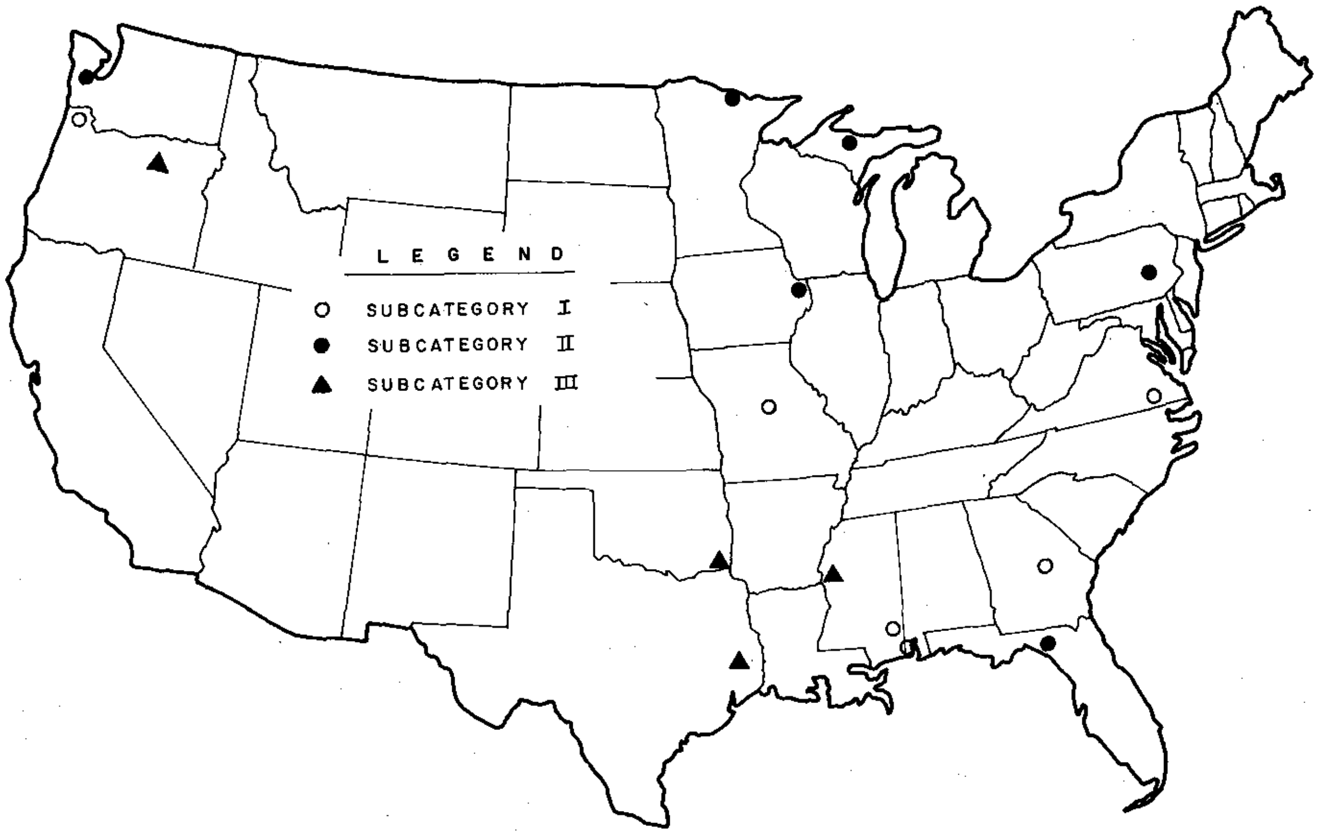


FIGURE 10 MAP OF INSULATION BOARD LOCATIONS

TABLE 6

INVENTORY OF INSULATION BOARD PLANTS

Abitibi Corporation
Blounstown, Florida

Armstrong Cork Company
Macon, Georgia

Boise Cascade Corporation
Internation Falls, Minnesota

The Celotex Corporation
Dubuque, Iowa

The Celotex Corporation
Marrero, Louisiana

The Celotex Corporation
L'Anse, Michigan

The Celotex Corporation
Sunbury, Pennsylvania

Flintkote Company
Meridian, Mississippi

Huebert Fiberboard, Inc.
Boonville, Missouri

Kaiser Gypsum Company, Inc.
St. Helens, Oregon

National Gypsum Company
Mobile, Alabama

Simpson Timber Company
Shelton, Washington

Southern Johns-Manville Products
Jarratt, Virginia

Temple Industries, Inc.
Diboll, Texas

United States Gypsum Company
Lisbon Falls, Maine

United States Gypsum Company
Greenville, Mississippi

United States Gypsum Company
Pilot Rock, Oregon

Weyerhaeuser Company
(Craig) Broken Bow, Oklahoma

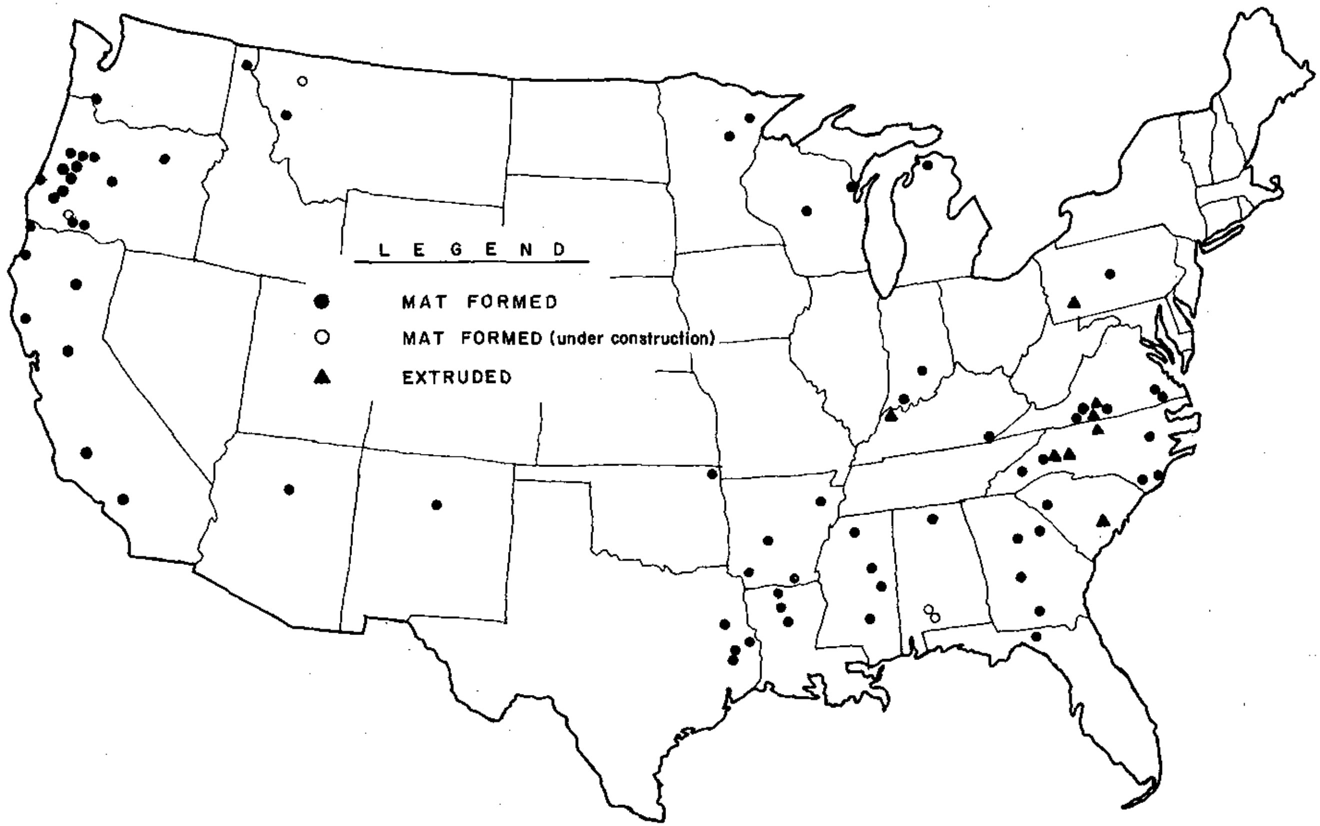


FIGURE 11 PARTICLEBOARD MANUFACTURING FACILITIES

TABLE 7

PARTICLEBOARD PRODUCTION PLANTS BY GEOGRAPHIC AREAS, 1973

Geographic Area	All Types	Number Producing Platenboard	Extruded Board
United States, Total	76	69	7
East	9	8	1
Pennsylvania	2	1	1
Indiana	2	2	-
Michigan	1	1	-
Wisconsin	2	2	-
Minnesota	2	2	-
South	40	34	6
Virginia	7	5	2
Florida	1	1	-
North Carolina	8	6	2
South Carolina	3	2	1
Georgia	2	2	-
Kentucky	2	1	1
Tennessee	1	1	-
Alabama	1	1	-
Mississippi	4	4	-
Arkansas	4	4	-
Texas	3	3	-
Louisiana	3	3	-
Oklahoma	1	1	-

TABLE 7 PARTICLEBOARD PRODUCING PLANTS
BY GEOGRAPHIC AREAS, 1973
(Continued)

Geographic Area	Number Producing		
	All Types	Platenboard	Extruded Board
West	27	27	7
Idaho	1	1	-
Montana	1	1	-
New Mexico	1	1	-
Arizona	1	1	-
Washington	1	1	-
Oregon	14	14	-
California	8	8	-

TABLE 8

UNITED STATES PARTICLEBOARD (MAT-FORMED) PRODUCERS

TABLE 8 UNITED STATES PARTICLEBOARD
(MAT-FORMED) PRODUCERS

ALABAMA

Giles & Kendall Company, Inc.
Maysville, Alabama

ARIZONA

Southwest Forest Industries
Flagstaff, Arizona

ARKANSAS

Georgia-Pacific Corporation
Crossett Division
Crossett, Arkansas

International Paper Company
Southern Kraft Division
Malvern, Arkansas

Permaneer Corporation
Hope, Arkansas

The Singer Company
Furniture Division
Trumann, Arkansas

CALIFORNIA

American Forest Products Corporation
Martell, California

Big Bear Board Products
Division of Golden State Building Products
Redlands, California

Champion International
Anderson, California

Collins Pine Company
Chester, California

Georgia-Pacific Corporation
Ukiah, California

Hambro Forest Products, Inc.
Crescent City, California

Humbolt Flakeboard
Arcata, California

Sequoia Forest Industries
Division Wickes Forest Industries
Chowchilla, California

FLORIDA

Florida Plywood
Greenville, Florida

GEORGIA

Georgia-Pacific Corporation
Vienna, Georgia

Weyerhaeuser Company
Adel, Georgia

IDAHO

Pack River Company
Tenex Division
Sandpoint, Idaho

INDIANA

Swain Industries, Inc.
Seymour, Indiana

Swain Industries, Inc.
Evanston, Indiana

KENTUCKY

Tenn-Flake Corporation
Middlesboro, Kentucky

LOUISIANA

Louisiana-Pacific Corporation
Urania, Louisiana

TABLE 8.
UNITED STATES PARTICLEBOARD (MAT-FORMED) PRODUCERS
(Continued)

Olinkraft, Inc.
Lillie, Louisiana

Willamette Industries, Inc.
Duraflake South, Inc. Division
Ruston, Louisiana

MICHIGAN

Champion International
Gaylord, Michigan

MINNESOTA

Blandin Wood Products Company
Grand Rapids, Minnesota

Cladwood Company
Division Forest Poducts Sales Co.
Virginia, Minnesota

MISSISSIPPI

Champion International
Oxford, Mississippi

Georgia-Pacific Corporation
Crossett Division
Louisville, Mississippi

Georgia-Pacific Corporation
Crossett Division
Taylorsville, Mississippi

Kroehler Manufacturing Company
Meridian, Mississippi

MONTANA

Evans Products Company
Missoula, Montana

NORTH CAROLINA

Broyhill Furniture Company
Broyhill, North Carolina

Carolina Forest Products, Inc.
Wilmington, North Carolina

Georgia-Pacific Corporation
Whiteville, North Carolina

International Paper Company
Southern Kraft Division
Farmville, North Carolina

Nu-Woods Incorporated
Lenoir, North Carolina

Permaneer Corporation
Black Mountain, North Carolina

OKLAHOMA

Ward Industries, Inc.
Miami, Oklahoma

OREGON

Boise Cascade Corporation
La Grande, Oregon

Cascade Fiber Company
Eugene, Oregon

Cladwood Company
Division Forest Products Sales
Sweet Home, Oregon

Fibreboard Corporation
Clear Fir Products Division
Springfield, Oregon

Permaneer Corporation
Brownsville, Oregon

TABLE 8
UNITED STATES PARTICLEBOARD (MAT-FORMED) PRODUCERS
(Continued)

Mexwood Products, Inc.
Albuquerque, New Mexico

Roseburg Lumber Company
Dillard, Oregon

Timber Products Company
Medford, Oregon

Weyerhaeuser Company
Klamath Falls, Oregon

Weyerhaeuser Company
Wood Products Division
North Bend, Oregon

Weyerhaeuser Company
Wood Products Division
Springfield, Oregon

Willamette Industries, Inc.
Duraflake Division
Albany, Oregon

Willamette Industries, Inc.
Brooks-Willamette Corporation
Division
Bend, Oregon

PENNSYLVANIA

Westvaco Corporation
Tyrone, Pennsylvania

SOUTH CAROLINA

Georgia-Pacific Corporation
Russellville, South Carolina

International Paper Company
Southern Kraft Division
Greenwood, South Carolina

TENNESSEE

Permaneer Corporation
Dillard, Oregon

Permaneer Corporation
White City, Oregon
Temple Industries
Diboll, Texas

Temple Industries
Pineland, Texas

Bassett Furniture Company
Basset, Virginia

Champion International
South Boston, Virginia

Masonite Corporation
Waveryly, Virginia

Stuart Lumber Company
Stuart, Virginia

Union Camp Corporation
Franklin, Virginia

WASHINGTON

International Paper Company
Long-Bell Division
Longview, Washington

WISCONSIN

Rodman Industries, Inc.
Resinwood Division
Marinette, Wisconsin

Weyerhaeuser Company
Marshfield, Wisconsin

Timber Harvesting

Timber may be harvested by one of four principal methods: (1) "selective cutting," in which particular trees are chosen for harvest; (2) "shelter wood," in which mature trees are removed in (2) such a manner as to leave an adequate overstory; (3) "seed tree harvesting," in which an area is clear cut to the extent that only sufficient trees are left to bear seed for natural reforestation; and (4) "clear-cutting," in which all trees are removed from the harvested area.

Transportation of Logs and Other Raw Materials

The transportation of logs after leaving the forest is accomplished primarily by truck and rail. In the Northwest, and Alaska, where waterways are accessible, a large number of logs are transported from the forest by navigable waterways. While this method of transportation may be in ships or on barges, it more commonly consists of large log rafts floating in the water. In most cases, the logs are transported from as little as several miles to as much as 161 km (100 miles) by truck or rail prior to being transported in water. Furthermore, the logs may be sorted in a fresh water pond before transport by truck or rail to the large floating log rafts.

Because of the magnitude of these operations, water transport of log rafts is generally limited to ocean or estuarine waters; but some fresh water rafting is practiced, particularly in the power supply reservoirs of the western U. S. Typically, a log raft is composed of millions of bd ft of logs, loose or bundled, and contained by perimeter logs. Log "driving", as practiced in the early years of the industry, is almost non-existent today. Log transportation in the South, East, and Midwest is almost exclusively by truck.

Other raw materials transported in the timber products industry may be broadly classified as fractionated wood. In the case of total tree harvesting, the resultant chips are trucked from the forest. While this type of immediate harvesting is a relatively new practice in the industry, it is expected to increase in the future. In general, wood chips resulting from in-field processing are commonly transported by truck or rail. While limited fluidization of chips, and hydraulic pipeline transfer, is practiced in the pulp and paper industry, this technique is used only as an inplant process in the remainder of the timber products industry. Pneumatic transportation of bark or sawdust is common for inplant transportation; however, between-plant transportation is accomplished by rail and occasionally by truck.

Raw Material Storage

The harvesting of timber is seasonal in most parts of the U. S. Consequently, log storage is often essential for continuous mill production. When fractionalized wood is used as a raw material, it is usually produced on a rather continuous basis, but it may arrive at the production site at irregular intervals, depending on the distance and method of transportation. For example, a train load of chips may arrive as infrequently as monthly at a plant site and a stockpile of chips must therefore be maintained. Management usually requires a "safety margin" of supply to accommodate non-shipment during supply interruptions, e.g., railroad workers' strikes. A stockpile of chips to supply two or three months production would be common. Generally, turn over times for stockpiles of raw materials for insulation board plants are less than one or two months and may be as low as three to six days. Stockpiles for overseas shipment are normally quite large and turnover times may be as long as several years.

Raw material storage is of considerable importance to the timber products industry and a large amount of planning and capital expenditure is involved. In addition, preservation of the raw material while in storage is necessary to insure that the quality and quantity of finished product is not impaired. Most of the techniques used for raw material storage and preservation involve the use of water and the ensuing production of water pollutants.

Logs may be stored either on the land or in the water. Those logs stored on land may be stacked in piles ranging from 20 to 33 ft (6 to 10m) in height and hundreds of feet in length. These piles, called "land decks", are usually one log's length in width. When logs are land decked, there exists a tendency for the ends of the logs to dry and crack. This "end-checking" diminishes the amount of usable, top grade lumber that can be obtained from the logs. To prevent end-checking it is not uncommon to sprinkle the decks with water. Because of almost continuous rains in the winter, spraying of land decks is seasonal on the Northwestern Coast. In other areas, such as the Southeast, it is practiced on a continuous basis. A sprayed land deck is referred to in the industry as a "wet deck." In some cases, the effluent from the wet deck is collected and recycled, but more commonly it is directly discharged. Quite often runoff from the wet deck flows into a log pond.

Logs may be stored in water either singularly or in bundles. If logs are stored as bundles, they are usually sorted on land, but, in some cases, may be sorted in the water prior to storage. There are usually two or more logs on the top of bundles that are held above the water because of buoyancy and do not benefit from the water storage; however, the number of logs that can be stored in the same body of water is considerably greater when the logs are bundled.

Logs may be stored in log ponds, river impoundments, or directly in marine or estuarine waters. A log pond may be defined as a body of water in which the influent and effluent are either small or controlled. Most ponds range between 0.5 to 16 ha (1.2 to 40 ac) in size. Typically one to three m (four to ten ft) in depth, some may serve as catch basins for drainage areas many times their size, though normally the associated drainage areas are relatively small. Most log ponds serve as a means of transporting logs to a mill located on their shores. Because the equipment at the mill that receives the logs cannot tolerate wide fluctuations, in pond water level most log ponds attempt to control pond level fluctuations. While there are a few log ponds used only for storage and sorting, most are associated with some type of mill operation. Log ponds are confined almost exclusively to the Northwest.

An impoundment of sufficient depth for log storage may be formed by the construction of a dam across a river. Logs are usually transported to impoundments by trucks and the confinement serves as a convenient means of sorting and storing the logs. An impoundment is subject to the same types of operational restrictions as log ponds with the primary difference being that the flow of water through such an impoundment is usually much greater than the flow through a log pond. In addition, these reservoirs are usually public waters whereas log ponds are privately owned. Some logs are stored in fresh water impoundments when the primary function of the impoundment is other than log storage. Power reservoirs and flood control reservoirs are occasionally used for log storage, but the extreme water level fluctuations characteristic of these waters make operations difficult, limiting their usage. Logs are often stored in estuarine and ocean waters, particularly in the Northwest and Alaska, sometimes as long as 20 years. These logs are placed into the water, sorted, and stored in a protected cove or bay in piles away from the shore. Provision is made for water level changes with the tides.

Wood chips, planer shavings, sawdust, and bark may be either raw materials or waste products in different segments of the forest products industry. As raw materials, fractionalized wood is commonly placed in uncovered piles. The residence time of a particle in the storage pile depends on the rates at which the particles are supplied and utilized, as well as the operational safety margin required by management. The production or usage rate combined with the mean residence time establishes pile size. A pile may be as small as a single truck load or as large as several hectares and up to 30 m (100 ft) in height.

The particles are usually conveyed pneumatically onto the pile and, the particles may be wetted during the blowing process, if dust is a problem. In some cases, both the introduction of particles to the pile and their removal occurs on the top of the pile and results in some of the particles in the bottom of the pile residing much longer than the mean residence time. In other cases, particles are added and removed from one side of the pile which causes those particles on the back side of the pile to have a residence time much longer than the mean. Chip and planer shaving piles used as raw materials in the particleboard industry are usually stored inside buildings to keep the moisture content of the chips as low as possible. Sawdust from very small sawmills may be stored on-site in piles for more than one year, and in many cases are left indefinintely.

Sawmills and Planing Mills

The primary function of any sawmill is to reduce a log or cant to a usable end product. The process employed to accomplish this function consists of a combination of basic unit operations including the following:

- mill feed
- log washing
- debarking
- sawing
- resawing
- edging
- trimming
- lumber handling
- lumber finishing

It should be emphasized that several of the above operations may not be practiced at a specific plant. The following process description is a discussion of operations listed above including a discussion of some of the variations within each unit that are most common in the industry.

Mill Feed - The majority of mills utilizing land storage of logs as opposed to water storage are fed by using a variety of loading equipment, most commonly front-end loaders. The loader picks up the log and simply places it on a ramp or deck equipped with moving chains which transport the log into the mill. Some mills, however, utilize ponds or flumes for mill feeding purposes. Ponds may be used for sorting and washing prior to entering the mill. Ponds and other water bodies used for storage are also used for sorting purposes. Log flumes are utilized for mill feeding by relatively few sawmills. In those mills utilizing flumes, ponds or other water bodies for feeding, the logs are floated to the mill entrance where a chain belt or bull chain carries the logs out of the water and into the mill.

Log Washing - Log washing may be practical prior to barking and/or sawing. While the desirability or necessity of this practice cannot be clearly established, some of the reasons for its use are as follows: (1) Where bark is utilized as a fuel, log washing prior to barking reduces the amount of slag buildup on boiler grates and, consequently, reduces frequency of grate washdown. Also, if bark is used for other purposed, a minimal amount of grit is desirable; and (2) for mills not barking prior to sawing, log washing increases saw life.

Log washing is accomplished by spraying water on logs from fixed nozzles as the logs are tranported into the mill. In practice, pressure and volume of water utilized vary from mill to mill, but pressures are on the order of 6.8 atmospheres (100 lb per sq in) while the volume of water varies from less than 5 to 17 lps (80 to 265 gpm).

The future of log washing will be a function of one or more of several considerations. If the trend in log storage is toward deck storage, wet or dry, rather than toward storage in log ponds, log washing may increase since log ponds serve the purpose of cleaning logs. If the use of bark as an energy source increases or decreases significantly log washing will possibly vary proportionately because log washing reduces slag buildup on boiler grates. If the market for "dirty" chips (i.e., chips and bark mixed together) increases significantly, the desirability for bark removal may decrease, while the desirability for log washing would increase. Also, changes in the market value of bark would likewise influence the degree of log washing and could possibly result in the adoption of bark washing. Based on the above considerations, the desirability of log washing will likely increase in the future.

Headrig Operation - The term headrig is used by the industry to include all the machinery which is utilized to produce the initial breakdown of a log to boards, dimensions or cants. Thus, a headrig includes the feed works, the setworks, the carriage and shotgun, the headsaw, chipper or chipper saw and all the controls associated with the above. The major types of headrigs and the basic mechanical components will be discussed.

The basic headrig consists of a single diesel or electric powered circular saw and a log carriage. The carriage is a platform on wheels equipped with hydraulic or electric setworks which hold the log as the carriage moves parallel to the saw. The setworks, which are controlled by the sawyer, position the log for sawing. The carriage is powered by a shotgun which may be air, hydraulic, or steam powered. The shotgun is a long, circular tube in which a ram is inserted. One end of the ram is attached to the carriage and the other is fitted with a pistonhead. A compressor or pump pressurizes the working fluid behind the piston and thus powers the carriage in one direction. By rotating a valve spool the sawyer can reverse the direction of the piston and the carriage. Figure 12 gives an equipment layout for a hydraulic shotgun.

Another type of single saw headrig utilizes a band saw. A typical band saw is 25cm to 30cm (10 to 12 in) wide, 11 to 12 m (35 to 40 ft) long, and is mounted on two saw wheels, one above the other, each with a diameter of two to three m (six to ten ft). The band saw is tensioned and driven by the saw wheels and may be one-sided or two-sided. The log is placed on the carriage and sawn as it passes the saw which is moving vertically downward.

Ahead of either the band saw or the circular saw may be a chipper. The chipper is used to square the side of the log prior to sawing and thus eliminates the slab which would otherwise result from sawing.

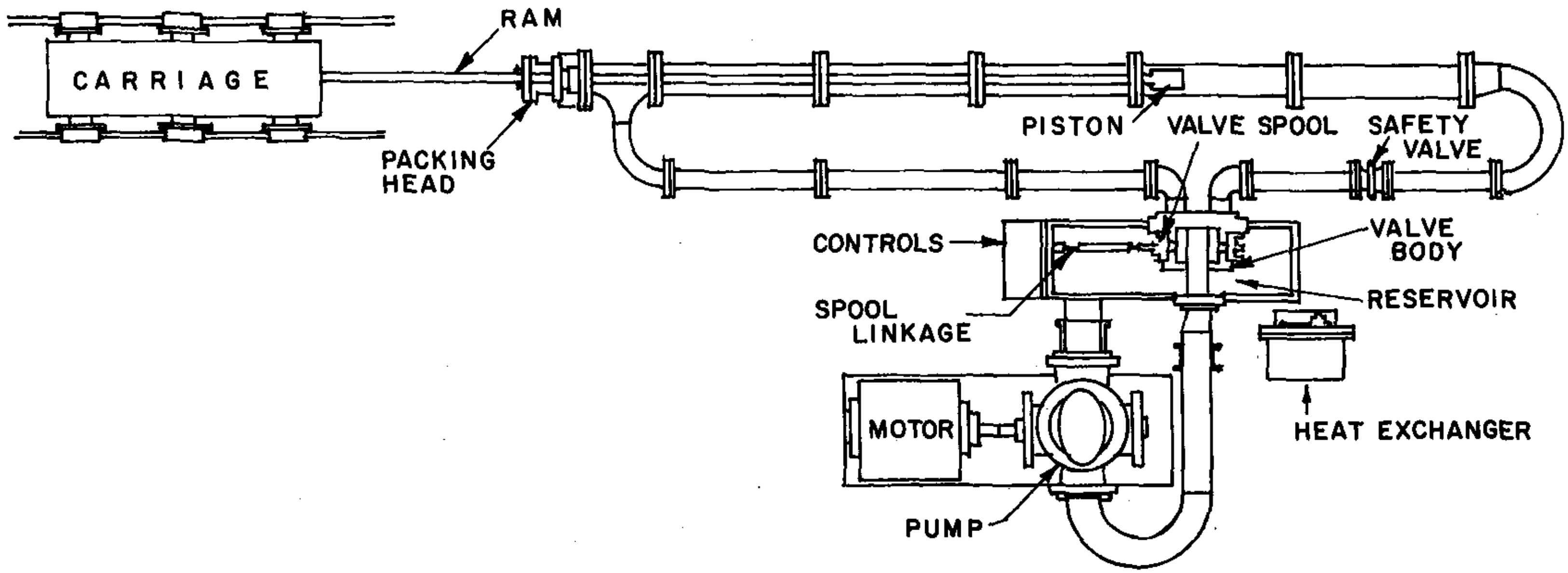


FIGURE 12 HYDRAULIC SHOTGUN

Multiple saw headrigs consist of the following basic types:

- Log gang mill
- Double band or quad band headrig
- Scrag mill
- Chipping headrig

The log gang or Swedish gang saw cuts by means of a series of parallel saw blades mounted in a frame that moves up and down as the log is fed through. The double band headrig utilizes a pair of band saws while a quadband headrig utilizes two pairs of band saws in tandem to accomplish the initial log breakdown. The scrag mill is generally utilized for small diameter logs and consists of one or more pairs of circular saws with each pair in tandem.

The purpose of the multiple saw headrig is to increase production efficiency by eliminating the need for several passes by the headsaw. This task may also be accomplished by a chipping headrig. In this type of headrig the debarked log is fed through an infeed section to bottom, side, and top chipping heads. The chipping heads are automatically set according to the diameter and shape of the log so that only that portion of the log which will not produce marketable lumber is chipped away. Thus, after chipping, the log has been completely profiled such that marketable lumber can be readily produced by subsequent operations. The subsequent operations are similar to those following other headrigs with the exception that from the chipping headrig the profiled log must proceed immediately to further breakdown without turning or changing position.

The nature of subsequent sawing operations will depend on the degree of breakdown accomplished in the headrig and the desired end product from the mill. In general, the function of these operations is to reduce the width or thickness of the lumber or to square the edges or ends. The basic unit operations following the headrig are gang sawing, resawing, edging, and trimming. The gang saw may be the reciprocating type, as previously described, or a set of circular saws usually of a movable, double arbor type. The gang saw reduces a cant to lumber of desired thickness. Resaws are usually vertical band saws and are used to saw thick boards into thinner ones. These may be single, double, or quad band resaws. Following resawing, or remanufacturing as it may be termed, the lumber enters the edger. Edgers vary widely in size and capacity but usually consist of one stationary circular saw and one or more circular saws that can be moved laterally on the arbor to permit ripping different widths. Trim saws are circular saws used to square the ends of the lumber and to remove serious defects.

Following edging and trimming, the rough green lumber is sorted and stacked. The lumber may first flow into a "green chain" and be graded, sorted, and stacked, or it may be graded and sorted by placing it in appropriate sorting troughs. If the lumber is to be marketed green, it may be passed through a preservative bath, usually pentachlorophenol, prior to stacking. The duration of the dip is usually less than one minute.

Dying of lumber is accomplished by either air seasoning or by kiln drying. Air seasoning is accomplished by segregating, coating, and piling. Segregation is done based upon green board weight so that a given pile will dry at the same rate. Prior to its being stacked, the lumber may be treated with chemicals by spraying, brushing, or dipping in order to prevent blue stain and other fungal attack. Various coatings may also be applied to the end of the lumber to retard checking. The most common of these is paraffin or other wax emulsions. The lumber is then stacked in such a manner as to provide adequate air circulation and left to dry for a period of time that may extend to several months.

Kiln drying is accomplished by placing green lumber into a humidity and temperature controlled kiln. The kiln is heated by steam or other means, generally by indirect radiation from coils. Air circulation is maintained by forced draft or by natural circulation. Humidity is controlled by steam sprays. The lumber is stacked mechanically or manually outside the kiln with sticks of wood used to separate the boards. The stacks are then moved into the kiln where they will remain until the desired moisture content is reached. Temperature, humidity, and drying time will vary with kiln type, wood species, initial moisture content, and various other factors. In general, however, kiln drying is accomplished in two to five days at dry-bulb temperatures ranging from 49 to 82 C (120 to 180 F). For some cases, high temperature drying, i.e., above 93 C (200 F) is also employed to reduce drying time.

Dried lumber is quite often planed to desired smoothness. The surfacing tools used are planer knives attached to a rotating cutterhead. The quality of finish is a function of the number of knives, the rotations per minute of the cutterhead, the feed rate of lumber through the planer, and other factors. Lumber may be surfaced on one, two, or four sides by the addition of an equal number of cutting heads.

After planing the lumber may proceed through one or more of the following processes:

Preservative dipping
Staining
End-coating
Moisture proofing

Preservative application is generally accomplished by the methods previously discussed for green lumber handling. Staining, usually with a water base material, is done merely to produce a more pleasing color in the finished lumber. This is generally accomplished by a spray nozzle as the lumber passes through the spray compartment. Excess spray is recirculated. End-coating prevents the ends of the lumber from checking while it is in storage or in service. This is generally done by spraying the end of the lumber with any of various materials such as paint or wax emulsions. Any material which will seal the end of the lumber and is easily applied will suffice. Moisture resistant compounds are sometimes sprayed on the finished lumber to increase durability and resistance to weathering. Compounds specifically formulated for this purpose are available from several manufacturers and are applied in a similar fashion to the stain application discussed above. These materials are generally water soluble.

As previously mentioned, a sawmill is a combination of some or all of the above unit operations. The process diagrams shown in figures 13 through 15 will serve to illustrate some of these possible combinations and some possible mill layouts.

Figure 13 illustrates a process layout for a small rough green sawmill. Figure 14 illustrates the combination of wet and dry deck storage of logs, with a small to medium size band sawmill and a planing mill. Figure 15 gives a possible layout for a medium to large sawmill.

It should be noted that planing mills may exist in combination with sawmills or may be independent mills buying from a number of suppliers. It should also be noted that other unit operations may be present at a sawmill or planing mill. The most common of these additional operations is edge or end jointing of lumber in sawmills and production of millwork in planing mills. These types of operations will be discussed below.

<u>Miscellaneous Operations</u> - There are a number of wood products which are produced by further processing or manufacturing of such primary forest products as lumber, plywood and board products. The large number of such products prohibits a discussion of detailed process descriptions for each individual product and since for the most part there is little or no process water used and little or no waste water generation in these processes, a thorough discussion of each manufacturing method is unnecessary. Basically the production of miscellaneous wood products may be characterized as one or more of the following unit operations: machining, fabrication, and by-product utilization. Representative examples of the specific products which are considered under these operations are given below.

<u>Machining</u>

shakes	door trim	wooden frames and sash
shingles	baseboards	window trim
excelsior	moldings	box cleats
barrel staves	wooden panels	spools
gun stocks	stair railings	flooring
wooden bowls	toothpicks	matches

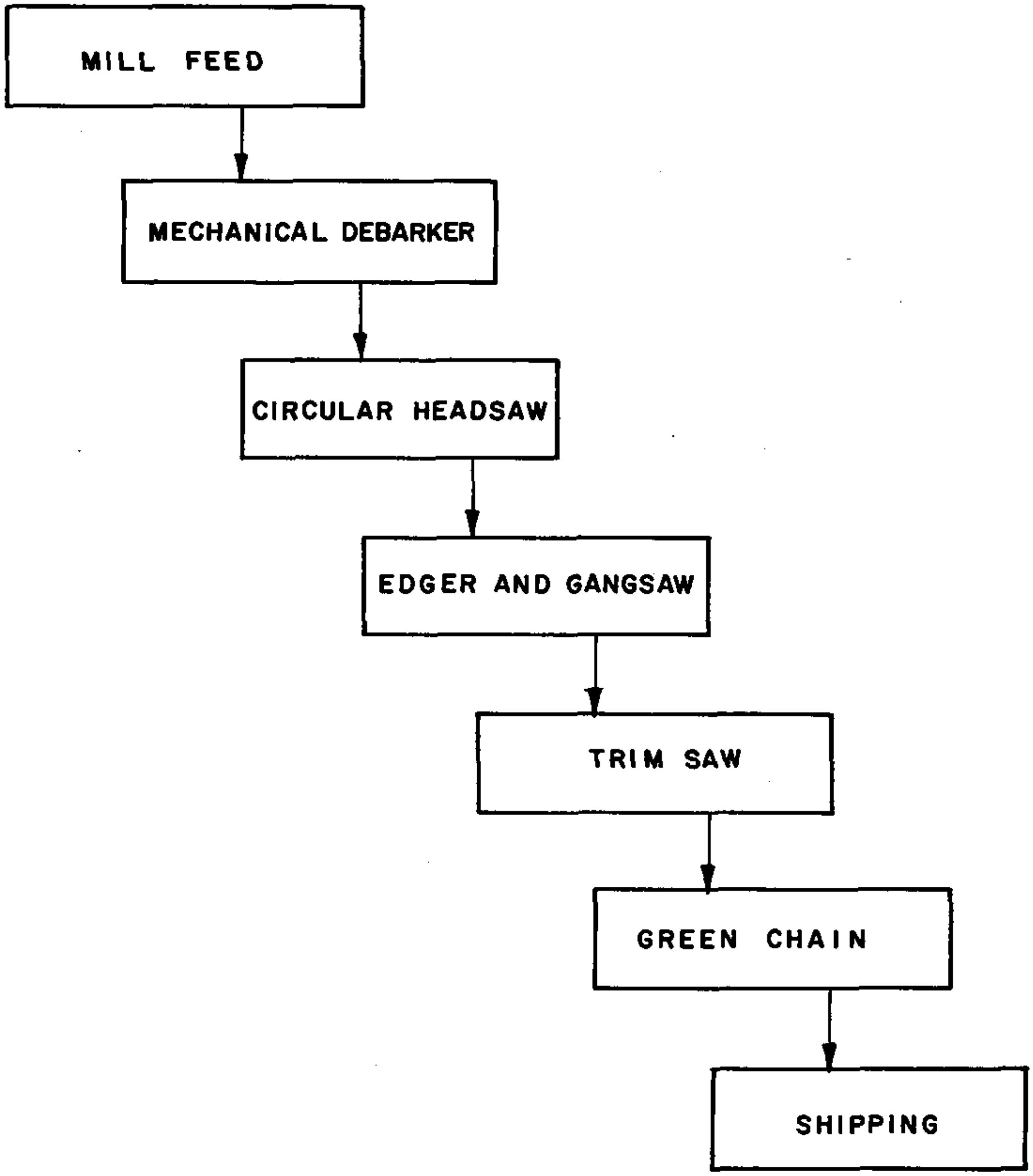


FIGURE 13 PROCESS DIAGRAM OF ROUGH GREEN SAWMILL

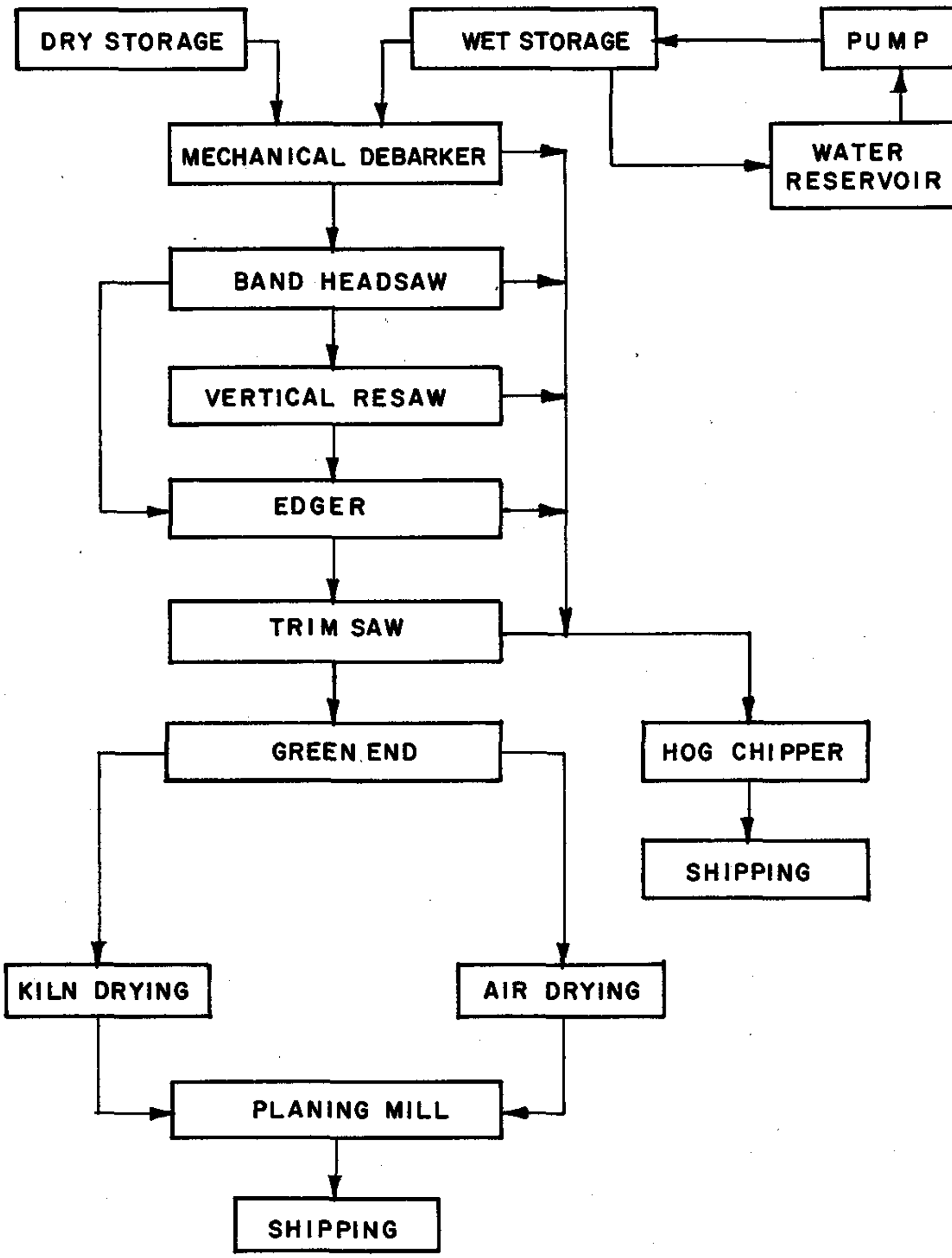


FIGURE 14 PROCESS DIAGRAM OF BAND SAWMILL

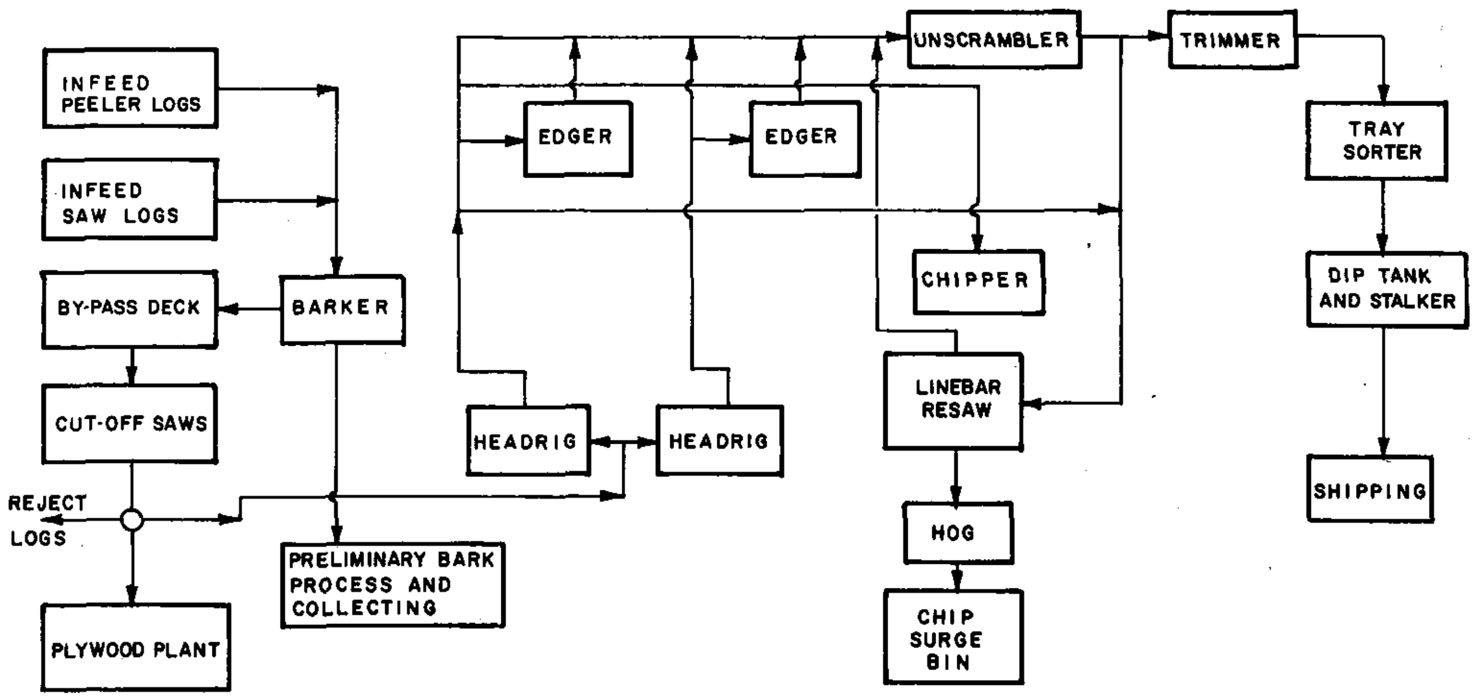


FIGURE 15 PROCESS DIAGRAM MULTIPLE HEADRIG SAWMILL

Fabricating

barrels	laminated beams	baskets
doors	laminated decking	wirebound boxes
windows	jointed lumber	wooden boxes
prefabricated buildings	wooden pipes	crates
mobile dwellings	trusses	

By-Product Utilization

wood flour	ornamental bark	bark mulch
toilet seats	chair seats	pressed logs

Machining - Machining is the process of shaping wood to a desired form and is accomplished by such basic mechanical operations as splitting, turning, carving, drilling, sawing, grooving, and lathing. Thus, shingles are manufactured from a block of wood by sawing at a slight angle to produce a flat piece of wood with one end thicker than the other. Moldings, trim, and other mill work are produced by lathing and grooving a piece of lumber to a desired shape. Cleats, used in crate manufacturing, are pro duced by sawing lumber into small shapes to be used in crate manufacture. A multitude of products are produced from lumber by such simple machining operations, but none are of significance with respect to waste water generation.

Fabrication - Fabrication is accomplished by mechanical fasteners or by use of adhesives. Where mechanical fasteners are employed no water usage is necessary. This is the case, for instance, in the manufacture of mobile homes, trusses, barrels, baskets, pallets, crates, and other fabricated products. The use of adhesives normally necessitates a certain amount of waste water because of cleanup operations.

The adhesives most commonly used in the wood products industry are given in Table 9. Of these, casein glue, protein, polyvinyl acetate, urea formaldehyde, melamine urea resin, and phenol resorcinol resins are most frequently used in fabrication. All of these are water soluble and, with the exception of polyvinyl and resorcinol resin, require water in preparation.

Fabrication with adhesives consists of jointing, adhering a flat sheet to a frame, or joining lumber face to face to produce structural materials. The standard glue joints are given in Figure 16. These joints are used for three basic purposes: to join lumber side-to-side-grain, end-to-side-grain or end-to-end-grain. Urea, modified urea, melamine urea, polyvinyl, casein, and phenol resorcinol are the most common adhesives for jointing. The finger joint is the predominant end to end joint utilized in the industry. Finger joints are produced by machining the ends of two pieces to be joined into fingers, applying adhesives to the fingers by brush or special roller applicators, and joining the pieces together. Curing time, temperature, and pressure will depend on the resin used. The amount of resin which must be applied varies with the type and purpose of the joint and is

TABLE 9
WOOD ADHESIVES: PROPERTIES, HANDLING AND USE GUIDE

	TYPES	CURING METHOD	SOLVENT	PREPAR-ATION	ADDI-TIVES	EXTEN-DERS	APPLICATION	PRESSURE	DURA-BILITY	ADVAN-TAGES	DISAD-VANTAGES	SPEC. & STANDARDS
Animal Glue	A,C-1,D	J-1	E	N,O	-	-	V-1,2,3,4	W-1,2	a	f,h,g	c	h
Casein Glue	A,D-2	J-1,2	E	O,P	P	-	V-1,2,3,4	W-1,2,3	a,Z	g	-	i,m
Protein Blend	A,D-2,D-3	I,J-1	E	O	-	-	V-1	W-1,2,3	a,Z	g	-	m,n
Soybean Glue	A,D-3	I,J-1	E	O	-	U	V-1	W-1,2,3	a,Z	g	-	n
Polyvinyl Acetate	B,C-2	J-1	E	N	-	-	V-1,2,3,4	W-1,2,3	a	f	c	l
Melamine Resin	B,D-2,D-3	I,K,L	E	O	-	S	V-1	W-1,2,3	X,Y	X	b	p
Urea Resin	B,D-1,2,3	I,J-1,K,L	E	O	-	S,R,U	V-1,3,4	W-1,2,3	Y,Z	g	d	m,j
Modified Urea Resin	B,D-1,2, D-3	I,J-1, K,L	E	O,Q	Q	S	V,1,3, 4	W-1,2, 3	Y,Z	-	-	k,m
Urea/Melamine Resin	B,C-1,D-1, 2,3	I,K,L	E	O	-	S	V-1,3, 4	W-1,2, 3	Y,Z	-	-	m
Urea Resorcinol Resin	B,C-1,D-2, 3	I,K,J	E	O	-	S	V-1,3	W-1,2, 3	Y,Z	-	-	m
Urea Resin Polyvinyl	B,C-1, 2	J-1	E	N,O	-	-	V-1,3 4	W-1,2	Z,a	-	-	m
Thermoset Polyvinyl	B,C-2	J-1,K, L	E	N	-	-	V-1,3 4	W-1,2, 3	Y	f	b	m
Contact Cement, Neoprene Rubber	B,C-1	J-1	G	N	-	-	V-1,3 4	W-1,2,3, 4	Y,Z	f	b	-
Phenolic Resin	B,C-1,D-1,2	I,M	E,F	N,O	-	R,S,T,U	V-1	W-1,2,3	X,Y	f	-	m,n,o,p,k
Resorcinol Resin	B,C-1	I,J-1,K,L	E,F	N	-	S	V-1,3	W-1,2,3	X	X	b	m,n,o,p,k
Resorcinol Phenolic	B,C-1	I,J-1, K,L	E,F	N	-	S	V-1,3	W-1,2,3	X	X	b	m,n,o,p,k
Epoxy Resin	B	I,J-1,K	H	N	-	-	V-1,3,4	W-1,2,3	Y	X	e	m

A Natural Origin
B Synthetic Resin
C Liquid
  1 Solution
  2 Emulsion
D Powder
  1 Dry Base Material
  2 All ingredients in powder, add to water

D continued
  3 Several ingredients needed
E Water
F Water and Alcohol
G Hexane and Methyl ethyl Ketone
H 100% solids
I Hot press

J Cold Press
  1 Room Temp. 70°F
  2 50° or above
K Kiln Cure (140°F or higher)
L Radio Frequency
M Electrical Resistance Heating

N Ready to use
O Mix with water
P Synthetic Latex
Q Furfuryl alcohol
R Wheat Flour
S Walnut Shells or Pecan Shells
T Co-cob for Furafil
U Soluble Blood

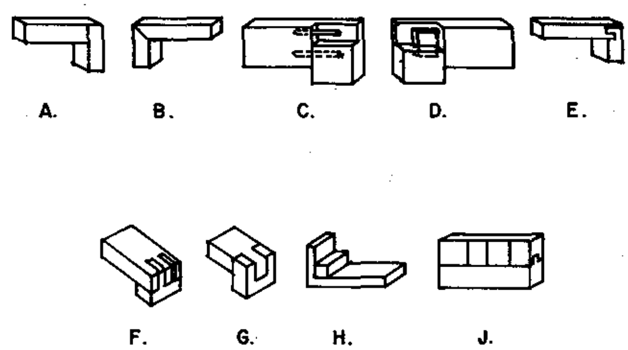
V 1 Spreader
  2 Dip
  3 Brush
  4 Spray
W 1 100 psi
  2 150 psi
  3 175 psi
  4 Squeeze rolls
X Waterproof
Y Highly water resistant
Z Moderately water resistant

a Dry, Interior use only
b High cost
c Poor water resistance
d Thick glue lines craze
e. Generates heat in mixing, requiring small mixes

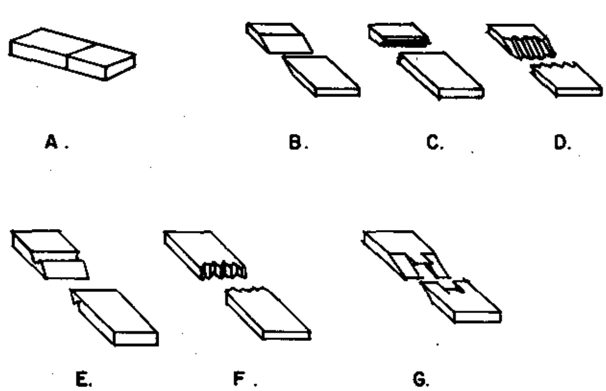
f Fast setting
g Low cost
h Fed, Spec, MMM-A-100
i Fed. Spec. MMM-A-125
j Fed. Spec. MMM-A-188
k Fed. Spec. MMM-A-00181

l Fed. Spec. MMM-A-193
m CS-35
n CS-45
o Mil..Spec. MIL-A-22397
p Mil, Spec. MIL-A-46051

SIDE-TO-SIDE-GRAIN JOINTS: (A) plain (B) tongue-and-groove



END-TO-SIDE-GRAIN JOINTS: (A) plain; (B) miter, (C) dowel, (D) mortise and tench, (E) dado tongue and rabbet, (F) slip or lock corner, (G) dovetail, (H) blocked, (J) tongue and groove.



END-TO-END-GRAIN JOINTS: (A) end butt, (B) plain scarf, (C) finger, (D) serrated scarf, (E) hooked scarf, (F) finger, (G) double-slope scarf.

FIGURE 16

usually measured only indirectly by testing the joint for strength. Similar assembly steps are utilized for end-to-side-grain joints and for side-to-side-grain joints. End-to-side-grain joints are employed in fabricating door frames of all types, window frames, and in lock corner boxes. Side-to-side-grain joints are utilized in flooring, decking, and in solid flush doors.

The application of a flat sheet to a frame is illustrated in door manufacturing. The flat sheet may be a door skin of various types which is pressed against a preglued frame in which case the adhesive used may be resorcinol, polyvinyl, contact cement, or some non-synthetic glue. This type of fabrication is also utilized to some extent in the building construction industry for adhering panels to frames or for adhering plywood to floor joists. The adhesive must likely to be used in this application is a mastic construction adhesive which is a thick dispersion of various elastomers in an organic solvent.

The third major fabrication operation to be considered is that of joining lumber face to face to produce structural members such as beams, arches, and timbers. Whether the process employed is automatic or manual, it basically consists of pregluing, gluing, fabricating and finishing. Pregluing operations include such previously mentioned operations as lumber drying, preservative dipping or spraying, planing, grading, end or edge jointing, and cutting to length. The dressed lumber, usually two in pine or fir, is end jointed or cut to the desired length of the final member. The lumber used to produce these laminates is graded and sorted. The high strength clear lumber is utilized in the high stress areas of the final product, which for beams is the top and bottom layers, while lower grade lumber is used for the lower stress areas of the member.

Following pregluing the laminates are spread with glue, commonly resorcinol and phenol resorcinol resin, by a double roll spreader or by an extruder applicator. The resins are mixed with a catalyst in small batches and are then fed to the roller-spreaders under pressure. The extrusion spreader requires no mixing tank, except for catalyst preparation, as the catalyst and resin are mixed in a helical mixing chamber within the spreader.

According to the Handbook of Adhesive Bonding, following gluing the laminates are assembled to form the beam and the resin is cured. Curing may be accomplished by cold setting, heat curing, or radio frequency curing. During curing, pressure is applied to the member. Special laminating clamps, generally of the screw type with rocker heads apply the required pressure. Both straight beams and curved arches can be produced in this manner by different arrangements of the clamp systems. After curing, which may take up to 24 hours, the member is finished by sanding or planing and prepared for shipment. A typical process diagram for a laminated timber manufacturing process is given in Figure 17.

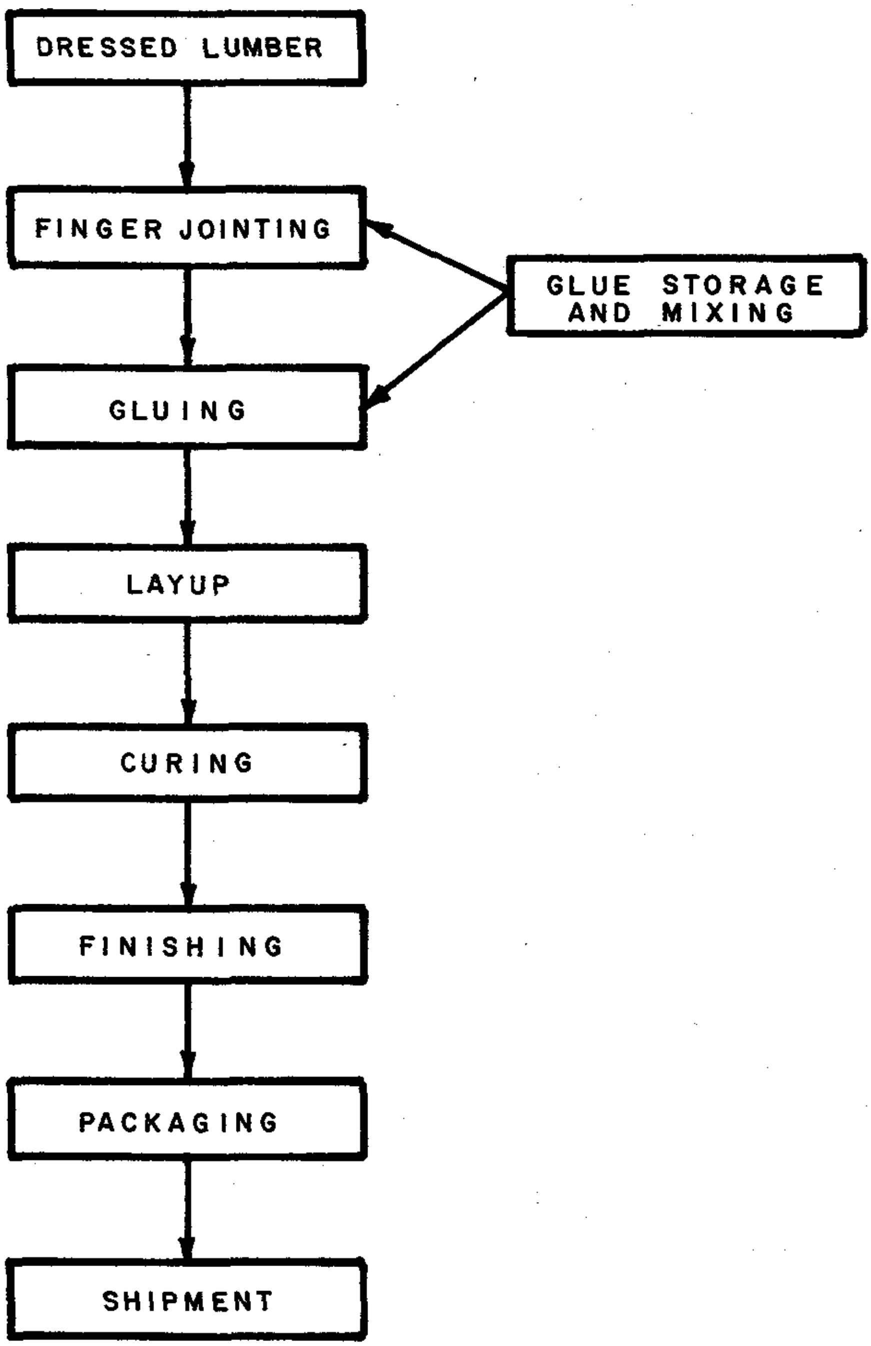


FIGURE 17 PROCESS DIAGRAM FOR LAMINATED TIMBER MANUFACTURE

By-product utilization covers those products in SIC 24 which utilize waste materials such as bark and sawdust as their raw material and are not covered elsewhere. As none of these products are significant sources of waste water, only a brief discussion of some of the major products follows:

Wood flour - Produced by attrition from planer dust or sawdust.
Pressed logs and briquettes - Produced by injecting sawdust into a mold under heat and pressure without chemical binders.
Mulch - Produced by hogging bark or sawdust to a fine particle size and possibly adding nitrogen in the form of liquid ammonia by spraying the ground bark.
Ornamental bark - Produced by classification of bark into a desired size category.
Molded Products - A small number of plants produce miscellaneous molded wood items from wood particles. The process consists of applying resin which is generally of the thermoplastic type to the wood particles following molding with heat and pressure. The resin content may be in the range of 30 - 40 percent by weight.

The term by-product utilization as defined in this document does not include the manufacture of insulation board and particleboard. These processes are discussed below.

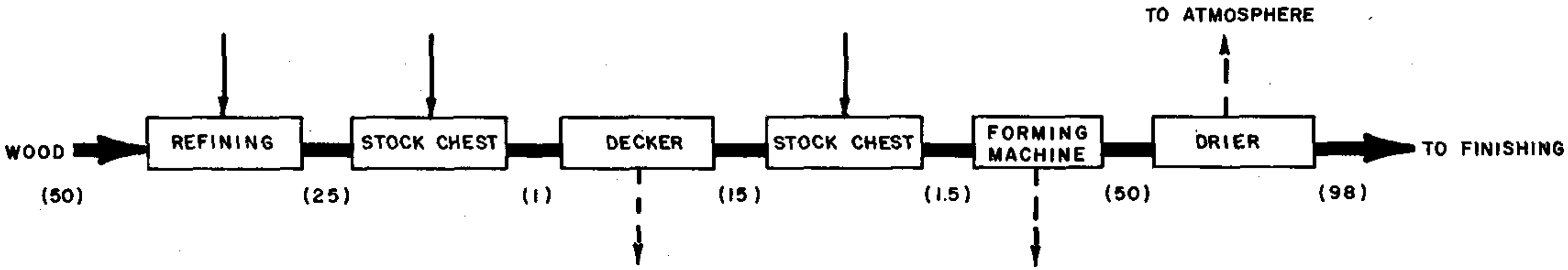
Insulation Board

Insulation board can be formed from a variety of raw materials including wood from a softwood and hardwood species, mineral fiber, waste paper, bagasse, and other fibrous materials. In this study, only those processes employing wood as the primary raw material are considered. Plants utilizing wood may receive it as roundwood or fractionated wood. Fractionated wood can be in the form of chips, sawdust, or planer shavings. Figure 18 provides an illustration of a representative insulation board process.

When roundwood is used as a raw material, it is usually shipped to the plant by rail or truck and stored in a dry deck before use. The round wood is usually debarked by drum or ring barkers before use, although in some operations a percentage of bark is allowable in the board. The barked wood then may be chipped, in which case the unit processes are the same as those plants using chips exclusively as raw materials. Those plants utilizing groundwood normally cut the logs into 1.2 to 1.5 m (4 to 5 ft) sections either before or after debarking so that they can be fed into the groundwood machines. The equipment used in these operations is similar to that used in the handling of raw materials in other segments of the timber products industry.

Fiber Preparation Operations

Ground wood is used in a number of insulation board plants in the U.S. It is usually produced in conventional pulpwood grinders equipped with coarse burred artificial stones of 16 to 25 grit



WATER IN

WATER OUT

(X) APPROXIMATE FIBER CONSISTENCY IN PROCESS

FIGURE 18 INSULATION BOARD PROCESS

with various patterns. The operation of the machine consists primarily of hydraulically forcing a piece of wood against a rotating stone mounted horizontally. The wood held against the abrasive surface of the revolving stone is reduced to fiber. Water is sprayed on the stone not only to carry away the fibers into the system, but also to keep the stone cool and clean and lubricate its surface. The water spray also reduces the possibility of fires occurring from the friction of the stone against the wood.

While most fractionated wood is purchased from other timber products operations, in some cases it is produced on site. Currently, little chipping occurs in the forest; however, in the future this is expected to become a major source of chips. Chips are usually transported to the plants in large trucks or rail cars. They are stored in piles which may be covered but are more often exposed. The chips may pass through a device used to remove metal grit, dirt, and other trash which could harm equipment and possibly cause plate damage in the refiners. This may be done wet or dry. Pulp preparation is usually accomplished by mechanical or thermo-mechanical refining.

Bagasse consists of the woody fibers and pith fractions remaining from the milling of sugar cane. It is delivered to the board plant by rail and truck from storage at the sugar mills in either loose piles or in bales. Moisture content can vary from 10 percent to 80 percent depending on the method of storage. Rigorous washing of the bagasse to remove remains of field trash and mud, in addition to the pith fractions, is a critical and necessary step in preparation for plant use.

<u>Refining Operations</u> - Mechanical refiners basically consist of two discs between which the chips or residues are passed. In a single disc mill, one disc rotates while the other is stationary. The feed material passes between the plates and is discharged at the bottom of the case. The two discs in double disc mills rotate in opposite directions, but the product flows are similar to a single disc mill. Disc mills produce fibers that may pass through a 30 or 40 mesh screen, although about 60 percent of the fibers will not pass through a 65 mesh screen. The discs plates generally rotate at 1,200 or 1,800 rpm or a relative speed of 2,400 or 3,600 rpm for a double disc mill. Plate separations are generally less than 0.10 cm (0.040 in). A variety of disc patterns are available and the particular pattern used depends on the feed's characteristics and type of fiber desired.

A thermo-mechanical refiner is basically the same as a disc refiner except that the feed material is subjected to a steam pressure of 4 to 15 atm (40 to 220 psi) for a period of time from one to 45 minutes before it enters the refiner. In some cases, the pressure continues through the actual refining process.

Pre-steaming softens the feed material and thus makes refining easier and provides savings on horespower requirements; however, yield may be reduced up to 10 percent. The longer the pretreatment and higher the pressure, the softer the wood becomes. The heat plasticizes primarily portions of the hemicellulose and lignin components of wood which bind the fibers together and result in a longer and stronger fiber produced.

Following the refining operation,, the fibers produced are diluted with water to a consistency amenable to screening. For most screening operations, consistency of approximately one percent fiber is required. Screening is done primarily to remove coarse fiber bundles, knots, and slivers. The coarse material may be recycled and passed through secondary refiners which further reduce the rejects into usable fibers for return to the process. After screening, the fibers produced by any method may be sent to a decker or washer.

Decker Operations - Deckers are essentially rotating wire-covered cylinders, usually with an internal vacuum, into which the suspension of fibers in water is passed. The fibers are separated and the water is often recirculated back into the system, There are a number of reasons for deckering or washing, one of which is to clean the pulp. When cleaning the pulp, water may be sprayed on the decker as it rotates. The major reason for deckering, however, is for consistency control. While being variable on a plant-to-plant basis, the consistency of the pulp upon reaching the forming machine in any insulation board process is critical. By dewatering the pulp from the water suspension at this point, consistency can be controlled with greater accuracy. Washing of the pulp is sometimes desirable in order to remove dissolved solids and soluble organics which may result in surface flaws in the board. The high concentration of these substances tends to stay in the board and during the drying stages migrate to the surface. This results in stains when a finish is applied to the board.

After the washing or decking operation, the pulp is reslurried in stages from a consistency of 15 percent to the 1.5 percent required for the formation process. The initial dilution of approximately five percent consistency is usually followed by dilutions to three percent and finally, just prior to mat formation, a dilution to approximately 1.5 percent. This procedure is followed primarily for two reasons: (1) it allows for accurate consistency controls and more efficient dispersion of additives, and (2) it reduces the required pump and storage capacities for the pulp. During the various stages of dilution, additives are usually added to the pulp suspension. These range from 5 to 30 percent of the weight of the board depending on the product used. Additives may include: wax emulsion, paraffin, rosin, asphalt, starch, and polyelectrolytes. The purpose of additives is to give the board desired properties such as strength, dimensional stability, and water absorption resistance.

After passing through the series of storage and consistency controls, the fibers in some cases pass through a tune-up refiner. The fiberous slurry, at approximately 1.5 percent consistency, is then pumped into a forming machine which removes water from the pulp suspension and forms a mat.

Forming Operations - While there are various types of forming machines used to make insulation board, the two most common are the fourdrinier and the cylinder forming machines. The fourdrinier machine used in the manufacture of insulation board is similar in nature to those used in the manufacture of hardboard or paper. The stock (pulp slurry) is pumped into the head box and allowed to flow onto an endless traveling screen. The stock is spread evenly across the screen by special control devices and an interlaced fibrous blanket, referred to as a mat, is formed by allowing the dewatering of the stock through the screen by gravity. The partially formed mat traveling on the wire screen then passes through press rollers, some with a vacuum applied, for further dewatering.

Cylinder machines are basically large rotating drum vacuum filters with screens. Stock is pumped through a head box to a vat where a mat is formed by use of a vacuum on the screen imposed on the interior of the rotating drum. A portion of the rotating drum is immersed into the stock solution as indicated in Figure 19. As water is sucked through the screen, a mat is formed when the portion of the cylinder rotates above the water level in the tank and the required amount of fiber is deposited on the screen. The mat is further dewatered by the vacuum in the interior of the rotating drum and is then transferred off the cylinder onto a screen conveyor where it passes through roller presses as utilized in fourdrinier operations.

Both the fourdrinier and the cylinder machines produce a mat that leaves the roller press with a moisture content of 50 to 70 percent and the ability to support its own weight over short spans. At this point, the mat leaves the forming screen and continues its travel over a conveyor. The wet mat is then trimmed to width and cut off to length by a traveling saw which moves across the mat on a bias making a square cut without the necessity of stopping the continuous wetlap sheet.

After being cut to desired lengths, the mats are dried to a moisture content of five percent or less. Most dryers now in use are gas or oil fired tunnel dryers. Mats are conveyed on rollers through the tunnel with hot air being circulated throughout. Most dryers have eight to ten decks and various zones of heat to reduce the danger of fire. These heat zones allow for higher temperatures when the board is "wet" (where the mat first enters) and lower temperatures when the mat is almost dry.

The dried board than goes through various finishing operations such as painting, asphalt coating, and embossing. Those operations which manufacture decorative products will usually have finishing operations which use water-base paints containing such chemicals as inorganic pigments, i.e., clays, talc, carbonates, and certain amounts of binders such as starch, protein, PVA, PVAC, acrylics, urea formaldehyde resin, and

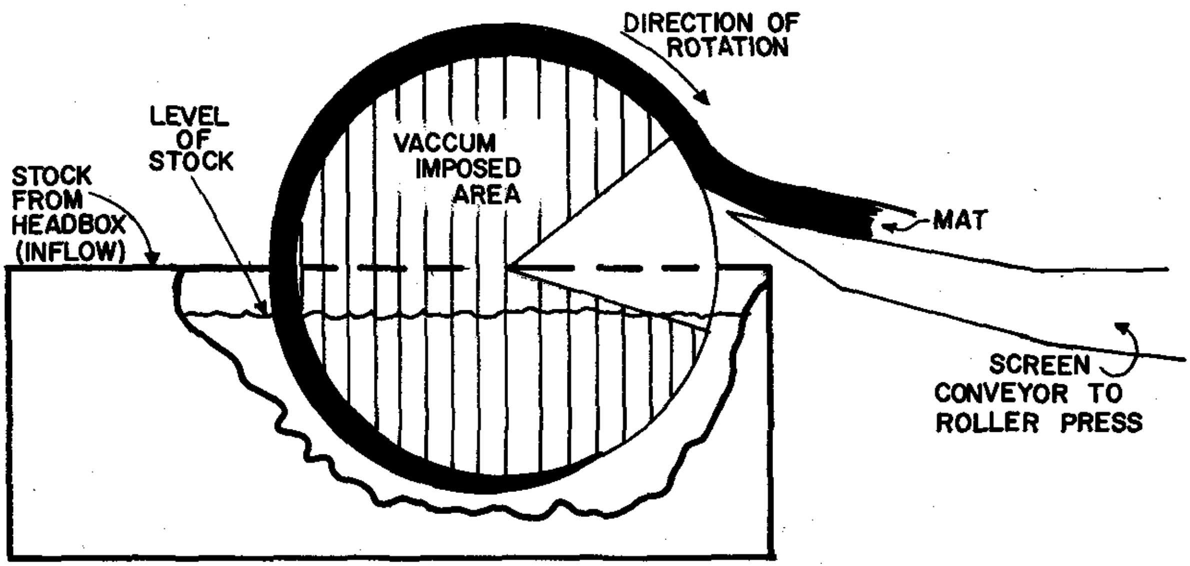

DIRECTION OF ROTATION
LEVEL OF STOCK
VACCUM IMPOSED AREA
STOCK FROM HEADBOX (INFLOW)
MAT
SCREEN CONVEYOR TO ROLLER PRESS

FIGURE 19

malamine formaldehyde resins. These are applied in stages by rollers, sprayers, or brushes. The decorative tile then may be embossed, beveled, or cut to size depending on the product desired.

The board sometimes receives addditional molten asphalt applications to one surface. It is then sprayed with water and stacked to allow adjustment to a uniform moisture content.

Hardboard is produced by some insulation board plants. Allowing the mats to age, redrying them, and pressing the mat by large steam heated hydraulic presses, consolidates the mat to the desired density.

Finishing operations such as sanding and sawing give the board the correct dimensions. Generally, the dust, trim, and reject materials created in finishing operations are recycled back into the process.

Particleboard

In the majority of cases the raw materials used to produce particleboard are wood residues of any species from other timber product processes. However, roundwood is used in a few instances. At this time, most particleboard in the U.S. is produced from mill residues such as planer shavings, sawdust, and plywood trim. Furniture waste, particleboard trim, veneer cores, and other chip sources are used occasionally. In cases where a particleboard plant is a part of an integrated complex, a substantial part, or all of the raw materials are supplied by other operations in the complex.

In other countries, logging residues are the primary source of raw materials. Logging residues arise from complete or near complete utilization of forested land and include chips, tops, and standing dead trees. It is projected that the use of forest residues in the U. S. will increase in the future, possibly causing a modification of the production process because of the necessity of washing logging residues to remove grit, sand, and other trash.

There is research presently being conducted in the U. S. and abroad on the utilization of other raw materials such as bark, wastepaper, and even municipal garbage (the paper and wood components after separation). The widespread utilization of these raw materials to produce specific grades of particlebaord will depend largely on both economics and scarcity of raw materials. In the case of bark utilization, the problems of disposal may be the catalyst needed to develop a utilization scheme. Sander dust (presently being used by some European mills in amounts up to 10 percent in boards) may be utilized in the future because of environmental considerations stemming from both air pollution and solid waste disposal problems.

The raw materials are shipped to the plant by rail or truck and stored in silos, covered sheds, or outside piles until needed. The fractionated wood is then conveyed pneumatically or mechanically to the particle preparation area. Before being reduced into particles, the raw materials pass through metering bins in order that a uniform feed rate can be achieved. (In some cases, the silos storing the received raw materials have metering capabilities.) The metered wood then goes to the particle preparation stage. Figure 20 shows a process flow diagram for particleboard production.

There are three basic steps is producing mat formed particleboard: particle preparation, mat formation, and mat consolidation. Incorporated within these primary operations are particle drying, additive blending, board cooling, and board finishing operations. It should be noted that differences in equipment among plants are common and the equipment is described in the general case only.

Classification - Prior or subsequent to particle preparation, it is usually necessary to classify the wood by size by the use of vibrating screens or air classifiers. The classification is done primarily to remove particles of undesired shape and size which, if allowed to remain, would increase the resin requirements, present problems during manufacture, or produce defects in the product. Another reason for classifying particles is to allow the use of the finer particles to form the face of the board and the coarser particles to form the core.

Screen classification is usually accomplished by vibrating screens. The wood is fed onto one end of the screen and the vibrating action of the screen transports the wood along the length of the screen. The rejects which are too large to pass through the screen are recycled back into a system such as a hammermill which reduces the size. The fines which are unacceptable for the process are discarded. Although in some cases air classification provides sharper fractionization, it can also involve greater difficulties in operation and controls. The use of air classification allows for the instantaneous adjustment of the classification process. However, it also entails a larger energy consumption than do screens.

Particle Preparation - The four principal methods of particle formation in use are hammermills, flakers, mechanical, and thermo-mechanical refining. Hammermills and similar type machines use free swinging hammers of steel strips or impellers with stiff arms to reduce material by a beating action. These are relatively simple machines with low cost wear parts. On certain raw materials and with the proper choice of hammermill, operating spped, feed rates and screen size the hammermill produces acceptable particle geometry at an acceptable cost. Under certain operating conditions, a high percentage of dust may be produced. These machines are used primarily for coarse jobs such as the reduction of large reject chips to a size acceptable for feeding flakers or refiners. These machines are also used to

FIGURE 20 PARTICLEBOARD PROCESS FLOW DIAGRAM

produce some core stock in particular operations. After the initial impact, particles that are still too large are pushed through a screen or grate at the periphery. The screen controls the size of the particles produced.

Flakers are used extensively in the particleboard industry for core stock and to some extent for face stock. Different flakers use either roundwood or residues as the feed; however, the basic concept of the machines, the use of knives to reduce the feed wood to particles, is the same. In the case of wood residue flakers, an impeller throws the residue against a ring of knives. The flakes thus produced are generally 0.05 to 0.15 cm (0.020 to 0.060 in) in thickness. Thirty to 40 percent of the particles produced are in the screen size range of four to ten with only two to ten percent being larger under normal conditions. Flakers used on roundwood operate on a similar principle in that logs are fed to a rotating set of knives. The resulting flakes are larger than those produced from residue but the thicknesses are comparable.

Mechanical refiners consist of two discs between which the chips or residues are passed. In a single disc attrition mill there is one rotating disc. The feed material passes between the rotating disc and a stationary plate and is discharged at the bottom of the case. Double disc mills have two discs rotating in opposite directions, but the product flow is similar to the single disc mill. The product of disc mills is generally an elongated rod shape. The disc plates generally rotate at 1,200 rpm or 1,600 rpm (a relative speed of 2,400 rpm or 3,600 rpm for a double disc mill). Plate separations are generally less than 0.10 cm (0.040 in). A variety of disc patterns are available and choice depends on the feed's characteristics and type of product desired. The products from these mills are generally used as face stock, i.e., the fiber is deposited on the surface of the board during formation to provide a smooth surface. When phenolic resins are used, the resin frequently is added during refining.

A thermo-mechanical disc refiner is basically a disc refiner receiving feed material which has been subjected to steam pressure four to 15 atm (60 to 220 psi) for a period of time (15 seconds to 3 minutes) before entering the refiner. The pressure continues through the actual refining (in the disc area), in most cases.

Pre-steaming softens the feed material and thus facilitates refining and reduces horsepower requirements. The longer the pretreatment and higher the pressure, the softer the wood becomes. The heat plasticizes primarily the hemicellulose and lignin components of wood which bind the fibers together. In addition, a longer and stronger fiber is produced.

<u>Drying</u> - Following particle preparation, the particles are dried by heat to achieve a uniform moisture content. The moisture content of the particle is critical and is different for various operations; however, the preferred moisture content of the

particles at the drier exit is usually between 5 and 15 percent. Driers are heated by gas, oil, wood residue unsuitable for particleboard (sander dust, etc.), or a combination of the above, but gas and oil fired driers are most common. The energy required per ton of particles is not an accurate measure of drier efficiency as the inlet moisture content will vary considerably depending on species and whether green or dry wood is used. Drier efficiency is usually discussed in terms of energy requirements per pound of water evaporated in the drier.

The rotary jet drum drier is essentially a horizontal pneumatic drier in which high velocity heated air is directed in such a manner that a sprial flow of particles is achieved through the drier.

Another type of drier in use is situated vertically and uses a fluidized bed principle. The particles enter the drier and are suspended by hot air entering from the bottom. The particles become lighter as they dry and are emitted from the top of the unit.

A third type of drier in use consists of a tube bundle rotating in a trough. The particles dry in contact with the tube bundles while vanes fitted to the bundles convey the particles. In some cases the particles enter a preheater before entering the drier. The preheater is usually heated by exhaust gases from the main drier.

Because of the nature of the drying operation (heating wood particles), there is always a risk of fire. Although maintenance and operational procedures generally keep fires at a minimum, dryer fires can still be expected to occur several times per year.

The most important operation in terms of the quality of the bond of the board and one of the more critical operations in the particleboard plant is the application of additives. The quantity of resin and the method of application are important factors in both cost and quality of the finished product.

The two most common types of resins used in manufacturing particleboard are urea-formaldehyde and phenol-formaldehyde, with the former accounting for approximately 90 percent of the usage in the U. S. Resin content in the board will range from 6 to 12 percent in the surface layers and 4 to 8 percent in the core. It is sometimes desirable to add 0.25 to 1.0 percent catalyst to urea resin to promote faster curing of the resin. The catalysts, consisting of acids or acid salts such as ammonium chloride, or ammonium sulfate promote faster curing by lowering the pH. The major disadvantage of adding a catalyst is a shortened resin pot life. Ammonium hydroxide may be added to retard the action of the acid until the pressing operation.

In addition to resins, a petroleum base wax sizing is usually added to the particles in the blenders. Sizing increases liquid water resistance considerably and vapor resistance to some extent.

The additives are applied to the particles in blenders of various types. A blender is basically a machine in which wood particles are agitated while a spray of resin and other additives are added in a manner that will allow uniform coverage of the additives on the wood particles. Each wood particle has adequate exposure in the blender to the spray. This insures a coating of the necessary quantity of resin and other additives which is necessary to achieve the desired properties in the final board. The additives may either be mixed together prior to blending or sprayed into the blender separately.

Although most plants currently use continuous blenders there are some batch blenders in use. A batch blender is operated by adding wood to a mix tank and agitating with a proportional amount of additives. While this system is considered by the industry to be reliable it is not economically feasible for large plants and is rarely used.

Continuous blenders consist of a longitudinal trough with a center shaft carrying mixing arms and spray nozzles for the dispersion of additives. There are two common types of continuous blenders. In one type the mixing arms rotate and cause a dense wood-air suspension. Spray nozzles located along the top eject atomized resin and other additives onto the particles in a uniform manner. The atomization is accomplished by compressed air, pressure spraying, or, in some cases, centrifugal means.

The most common type of continuous blender currently in use is the curtain spray blender. Particles are fed into one end of the blender in a falling curtain effect. Auxiliary curtains are created by the agitating action of paddles fixed to rotating mixer arms. Resin and other additives are added to this system by spray nozzles located in the end plate on the feed side of the blender. The curtain spray blender creates a thorough mixture of all the materials that will go into a board and many new plants are choosing this type of blender. One reason the trend is to the curtain spray blender is the availability of cooling jackets for reduction of the inside temperature. Blender cleaning is a necessary part of all blender operations since excess resin, as well as resin already on particles, sometimes adheres to the paddles and walls of the blenders. It is advantageous to maintain this buildup at a minimum level in order that the blenders can be used for longer periods of time and maintenance costs can be reduced. Since both urea and phenolic resins are thermosetting, the cooled blender will have less adhesion on the walls and will require cleaning less often. Also, the curtain-spray blenders have fewer nozzles to clean or plug up.

Formation of a uniform mat of particles is the single most important objective in a particleboard manufacturing process. A lack of uniformity will result in physical property variations, curing problems in the pressing cycle, and will tend to make the particleboard more subject to warp. Poor mat formation may also result in poor surface and edge characteristics which in turn affect the salability of the board.

Forming machines meter the particles from a surge area and spread them uniformly across the width of the machine onto a caul or moving screen. In addition, there is usually a particle orientation or leveling device to further provide for uniform formation. A surge area in a forming machine insures a continuity of material flow into the formation devices. It is important to maintain a uniform level in the surge bin. Without bulk density control there can be no uniform mat formed as the wood is generally metered volumetrically. The wood is metered onto the caul or moving screen by the means of rakes, picker rolls, or other such devices, although some machines use air as a metering technique. After the particles are distributed onto the caul or moving screen, there are usually leveling screws or picker rolls or shaveoffs to level the mat. To produce a layered board, the particles, which have been previously divided into fine and coarse materials, are laid by different machines to give fine surfaces and a coarse core to the board.

A variation of the layer board formation is the graded density board. This is formed by air classification and a gradual reduction of particle size occurs from the core to the surface. Graded density is accomplished by feeding particles at a volumetrically controlled rate through a central air distribution mechanism. The horizontal air flow acts as an air separator and the heaviest particles drop almost vertically, while the finer particles are thrown to the far edges.

Pressing - After formation the mats are conveyed to the pressing area. A prepress is often used when a caul-less system is being used or a thick board is being produced. The prepress, which may be of the single opening hydraulic type or the continuous roller type, is used to impart some integrity to the board before it enters the hot press. Also, before entering the hot press, the mats are usually trimmed by trim saws with the trim being recovered as furnish and fed back to the forming system.

The hot press is used to consolidate the mats under pressure and cure the resin with the heat from the steam heated platens. Some newer plants use resonance frequency devices to help cure the resin by heating the board internally with the use of high frequency radio waves. Resonance frequency pressing reduces press time and allows for the production of boards of greater thickness.

Pressing is accomplished by either multi-opening hydraulic presses, single opening hydraulic presses, or, occasionally, a continuous press. Multiopening presses consist of a number of shelves with each shelf containing a heated platen. The mats are stacked into a loader which in turn allows mats to be placed on all the shelves at once. Each press is usually constructed so that platens close simultaneously in order to prevent board defects. Single opening presses do not require loading racks. They operate in a similar manner as the multi-opening presses. The presses operate at pressures as great as 69 atm (1000 psi) and at temperatures of 132°C to 204°C (270°F to 400°F) depending upon the type of resin the process employed. Continuous presses consist of heated rolls and produce a continuous ribbon of board. After the ribbon leaves the press it is cut to the lengths required and sanded.

Extruded Particleboard

The raw materials utilized for extruded particleboard are usually dry wood with a large proportion of furniture scrap. Particle preparation is primarily accomplished by hammermills. After particle preparation and classification, the wood particles are coated with resin and wax by the previously described batch method. The coated particles are forced through a heated dye by hydraulic rams and the board emerges in a continuous strip which is cut to size. Since boards produced by the extrusion process are considerably stronger in one direction they are usually cross-banded with wood veneers to provide strength and stability.

Finishing Operations

Finishing is generally the final step, with the exception of packaging, in any timber products manufacturing process. It may consist of surface smoothing such as sanding or planing, covering with liquid coatings or covering with various sheet materials, or combinations of these operations. With the exception of the finishing processes previously discussed in connection with sawmilling and particleboard and insulation board manufacturing, the manufacture of prefinished panels and the finishing associated with mill work and molding are the major product areas of significance for the purposes of this study.

Factory finishing of wood-based panel products involves the application of a wide variety of finishing materials of various formulations and the employment of various methods of application. In general, however, finishing materials can be classified as either liquid materials or sheet material overlays. Liquid finishes are supplied to almost all types of wood-based panels including softwood plywood, hardwood plywood, hardboard and particleboard. For any particular finishing operation, the finishing material used and the method of application are primarily dependent upon the type of panel being finished as well as the desired final properties of the finished product. Liquid finishing materials are most commonly applied by one of the following methods: spray coating, curtain coating, direct roll coating, reverse roll coating, or knife coating. Each of these methods usually involves the employment of a coating machine through which the panel substrates pass in a horizontal position, on a continuous basis by way of a conveyor system.

Spray coating is a method used on almost all types of substrates and is used in the application of various liquid finishing materials including clear and pigmented paints and coatings. The spray of material is most commonly produced by fixed gun spray, reciprocating spray, or rotary arm spray equipment. The spray equipment is commonly enclosed in a spray booth to provide fire and air pollution protection by removal of both the solvent fumes and the spray mist generated from spray coating operations. Two types of spray booths include a water wash type, which employs a thin water curtain as the filtering media, and a dry type which employs a dry filter element. Spray coatings are especially important in the application of certain textured surfaces.

Curtain coating is a common method of applying various types of coatings to flat, smooth panel substrate surfaces. The curtain coater produces a thin, uniform curtain-like film of liquid material which falls by gravity to the panel substrate as it passes through the coating zone. The curtain-like film is produced as the liquid material passes through over head knife gates under either a gravity head or a pressure head. Excess curtain flow is caught by a return trough and is returned to the receiving tank for reapplication.

The direct roll coater is probably one of the most commonly used applicators for flat stock panel substrates. A roll coater generally consists of an applicator roll, a metering roll, and a feed or support roll. The applicator roll and the metering roll rotate in opposite directions on the upper side of the panel substrate and the liquid material is flooded over and between these two rolls. The metering roll, of smaller diameter than the applicator roll, serves to control the thickness of the liquid material film on the applicator roll which applies the material directly to the panel substrate as it is passed through the coating device by the feed roll on the under side of the panel. Excess liquid material is caught by a recovery pan and is returned to the receiving tank.

Reverse roll coating is particularly important in the application of high viscosity filler materials of high solids content. The reverse roll coater basically consists of the same three components of the direct roll coater plus an additional component, a reverse wiping roll which rotates in the opposite direction of the applicator roll. The essential purpose of the wiping roll is to more effectively force the material into the surface voids of the panel substrate and to provide a smooth troweled surface coating. As with the direct roll coater, the excess material is collected and returned to the material supply for reapplication.

Knife coating is also especially suited for applying high viscosity liquid finishing materials of high solids content. The knife coater basically consists of an applicator roll, a duplex doctor blade assembly and support and feed rolls. The applicator roll first applies an excess amount of material to the panel substrate in much the same manner as described above for direct roll coating. The duplex doctor blade consists of a rigid bullnosed blade which first scrapes off the majority of the excess material and a more flexible blade which scrapes the surface of the panel clean, leaving only the surface voids filled with coating material. The excess material is also collected for reapplication.

Liquid finishing materials vary widely and cannot be defined as completely as the methods employed in their application. Finishing operations on all types of wood-based panel substrates usually involve the application of one or more of the following materials: patching materials, sealers, stains and dyes, prime coatings and fillers, base or ground coatings, grain printing inks and top coatings. Patching materials are usually applied to hardwood plywood panels as the first step in the manufacturing of prefinished wall panels. The patching material, a thick putty-like substance, is manually applied using a flat blade putty knife to fill knot holes and other large surface defects in the hardwood face veneer of the panels.

Sealers of many different formulations are usually applied to almost all wood-based panels at sometime during the finishing operations. A variety of synthetic resin sealers are applied to softwood plywood, usually for the purpose of protection of the surface until final in-use finishing such as painting or varnishing. Sealers or primers of pigmented paint or lacquer types are often applied to hardwood plywood and particle board to provide a firm foundation for subsequent coatings. Sealers are usually applied by spray coating, roll coating, or curtain coating equipment.

Stains and dyes are used to some extent in the finishing of various types of wood-based panels. Conventional finishing of softwood plywood is commonly accomplished by spraying or flooding light or heavily pigmented penetrating stains which will not curl or flake upon checking of the panel face. Dying of hardboard is becoming less important but is still practiced to some extent in making floor tiles and similar products.

Prime coatings and fillers and frequently applied to nearly all types of wood-based panels. Prime coated panels are either marketed as such or receive further finishing at the factory level. The primary purpose of prime coating and filling is to improve the control and the quality of finish of materials to be applied in subsequent finishing operations on the prime coated panel. Prime coating of softwood plywood is often coupled with the use of a medium density paper overlay. The combination serves to improve surface qualities for paint finishes to be applied by the ultimate user. Fillers or high viscosity, heavily pigmented paint materials are applied to the face veneers of hardwood plywood and to the surfaces of particleboard to a great extent in the manufacturing of prefinished panels. The purpose of applying the filler material is to fill the small voids in the panel surface to provide a smooth flawless surface for subsequent finishing operations. Filler materials are usually applied either by a knife coater or a reverse roll coater. Presently, most filler materials are of a non-water solvent base, however, because of air pollution controls on solvent emissions from finishing lines, water base fillers are becoming more widely used.

Factory finishing of insulation board is a common practice in the case of both ceiling and interior wall panels which are being factory painted. Special fire-retardant paint formulations are often applied, usually by spray coating, to obtain an irregular surface to aid in sound absorption.

A Forest Products Journal investigation shows that prime-coatings are especially important in the manufacturing of hardboard panels. High viscosity, heavily pigmented paints which often act as fillers are applied to the hardboard panels employing either knife coaters or reverse coating of hardboard panels.

Base or ground coatings differ from prime coatings in that the former are usually associated with grain printing operations commonly used on hardboard panels, particleboard panels and hardwood plywood panels with face veneers of plain, unfigured character or color. After a filler coat is applied and cured a base coat is applied with either a curtain coater, roll coater or spray coater which provides a ground color for the grain to be printed. After curing the ground coat, grain designs are printed by one or more commonly by two or three roller or plate type printing machines to provide the panel with a simulated wood grain finish.

Presently, most inks used for grain printing are non-water base but water base inks are expected to become more popular in the near future.

Top coatings are often applied as a final factory finish coating and are used to a great extent in the finishing of nearly all prefinished panels. Top coatings for prefinished hardwood plywood panels are usually either a lacquer type or a synthetic conversion varnish type of which the alkyl urea resin type is the most important. Top coatings for hardboard are of various types including alykl or melamine based varnishes. Clear and pigmented polyester and acrylic finishes are transparent lacquers. Water base top coats are also being used on various types of prefinished panels.

Figure 21 shows a process flow diagram for the manufacturing of printed grain wall paneling. Although the process shown is not necessarily typical of any particular plant or type of panel, it should serve here to illustrate some of the processes that have been discussed with respect to the application of liquid finishing materials to wood-based panels. As shown in the diagram, the panels are introduced into the continuous prefinishing line and are first cut to size and then rough sanded, usually by large belt sanders. The V or U-grooves are then machine cut and painted. Currently groove paints are mainly

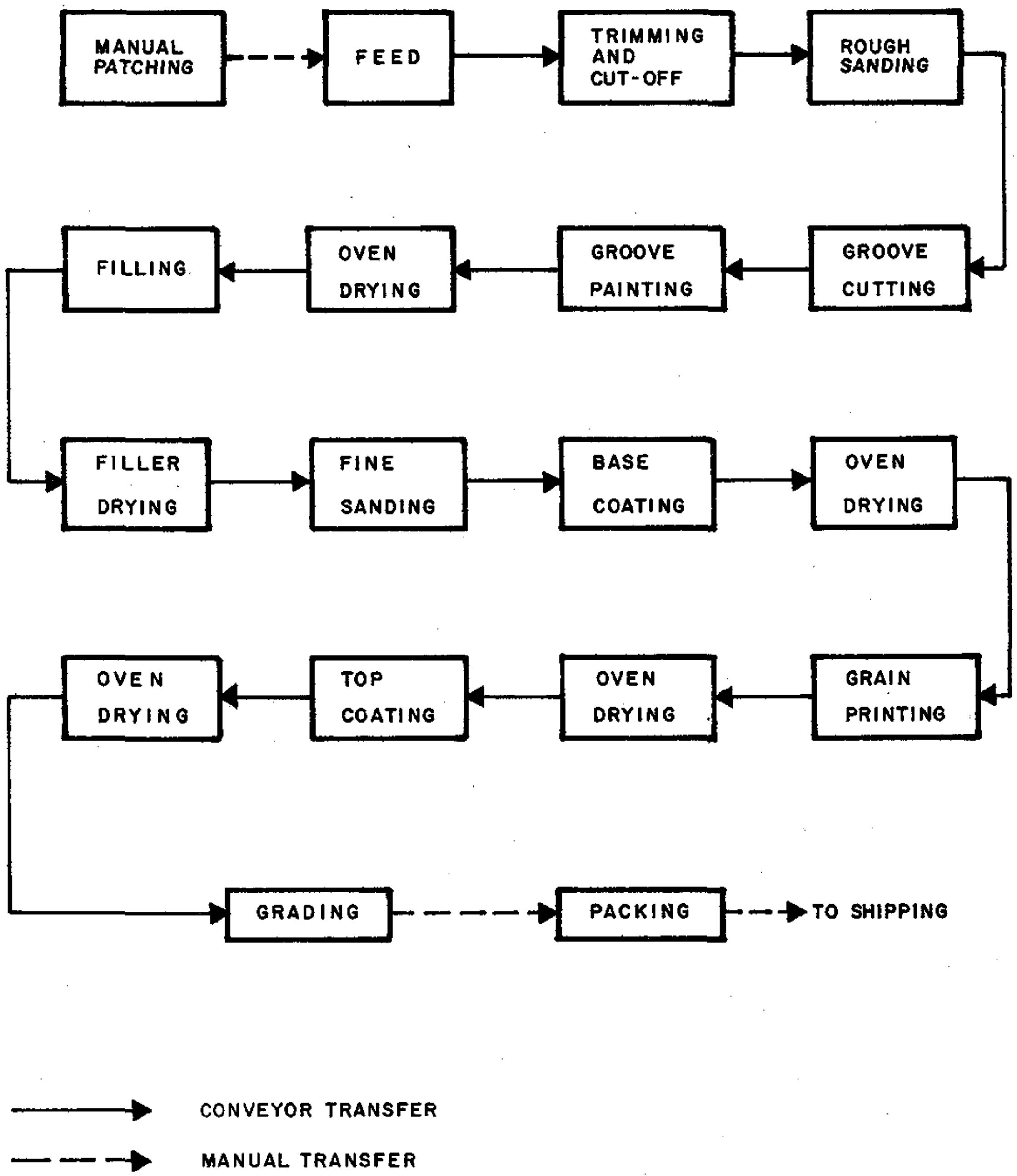


FIGURE 21 PROCESS FLOW DIAGRAM FOR THE MANUFACTURE OF PRINTED GRAIN PRE-FINISHED PANELING

non-water solvent base but water-base paints are gaining popularity for this application. After the groove paint is oven dried, the panels are then machine filled by either a reverse roll coater or a knife coater and the filler is then oven dried. The filled panels are sometimes fine sanded before the application of the base coat which also must be dried. The imitation grain is then printed on the panels and dried, followed by the application of the top coat. After top coat drying the panels are then graded and packaged for shipment.

Overlaying operations in the factory finishing of wood-based panels involves various types of sheet materials being bonded to the base panel by glue or cement materials of various types. The primary purposes of overlaying are to mask defects, protect against weathering, provide a base for paints and other finishes, increase the strength, hardness or abrasive resistance of the surface, provide decorative effects, or a combination of any of these attributes. The most important types of overlaying materials are resin-impregnated papers, special plastic film and aluminum foils. Resin-impregnated paper overlays are used on all types of wood-based panels, The resin-impregnated papers of widely varying resin content are usually bonded to the wood-based panel under high temperatures and pressures. Temperature ranges of 93 to 149°C (200 to 300 F) and pressure of 8 to 28 atm (118 to 412 psi) are employed depending on the resin type and content and on the type of base panel being overlaid. Except in the production of abrasion resistant surfaces, most overlaying operations involve low pressure systems. For surfaces where high resistance to abrasion is required, high pressure laminating of a clear melamine protective sheet is often added to the overlayed panel.

The most common types of resins used in resin-impregnated paper overlaying are melamine formaldehyde, phenol formaldehyde, polyesters, and acrylic types. The first three types are thermosetting resins which undergo permanent physical and chemical changes through the application of heat and pressure. In contrast, the acrylic types are thermoplastic resins which soften and may be reformed under pressure and heat. The melamine and phenol-formaldehyde resins are usually added to kraft paper at the pulp mill to produce either high or medium density impregnated paper to be overlaid at the panel finishing plant. High density impregnated paper requires no additional adhesive for bonding to the wood substrate while medium density overlays usually require a phenolic glue line in the overlaying operation. The polyester impregnated papers are also self-bonding while overlaying of the acrylic types usually employs a phenolic glue line.

Special plastic films of various types may be used to overlay almost all types of wood-based panels. Vinyl resin films are being used to a large extent. Polyvinyl chloride films are used in producing textured and printed decorative panels. Clear vinyl films are also important in finishing hardwood plywood wall panels. Bonding of the vinyl film is usually accomplished through the application of either polyvinyl acetate water-emulsion adhesives or solvent-type elastomeric adhesives. The polyvinyl acetate is a thermoplastic resin formed by polymerization of vinyl acetate. The adhesive is either applied to the wood-based panel or to the vinyl film and is often dried to remove the solvent, then heat activated before joining the two materials. The overlayed panel is usually pressed between two rubber rollers to improve the bond.

Aluminum foil overlayed panels are being produced on a relatively small scale basis. Bonding of the foil is often accomplished by using modified phenolic resin film glue and employing a press operation. Adhesives used in the overlaying operations discussed above can be applied in a number of ways, but the most common method is by roll coating the adhesive onto the panel substrate prior to the application of the sheet material overlay.

Other types of overlaying operations practiced on a relatively small scale basis involve the overlaying of hardboard and veneers onto particleboard panel substrates. Adhesives used in these operations are most commonly phenolic or urea resin glues used in conjunction with a hot pressing operation. However, vinyl glues and various contact cements can also be used in a cold pressing operation.

Figure 22 shows a simplified process flow diagram for the manufacturing of vinyl film overlayed panels. Although this is not typical of all overlaying operations, it is presented here to illustrate some of the basic operations involved in overlaying wood-based panels. The panels are first fed into the continuous system and are often sanded prior to the application of the adhesive which is commonly applied by a roller coater. Often the solvent is dried immediately after application of the adhesive and then heat activated before application of the vinyl film. After the vinyl sheet material is applied, the composite panel is then passed between two rubber rollers to improve the bond. Excess vinyl material on the edges of the panel is trimmed flush with the panel edge. The finished, overlayed panels are then graded and packaged for shipping.

Molding is produced by planing, grooving or otherwise manufacturing through a molding machine. Finishing generally consists of priming and painting, or filling followed by wood grain printing or vinyl film application. The finishing materials utilized are generally the same as those utilized for prefinished panels.

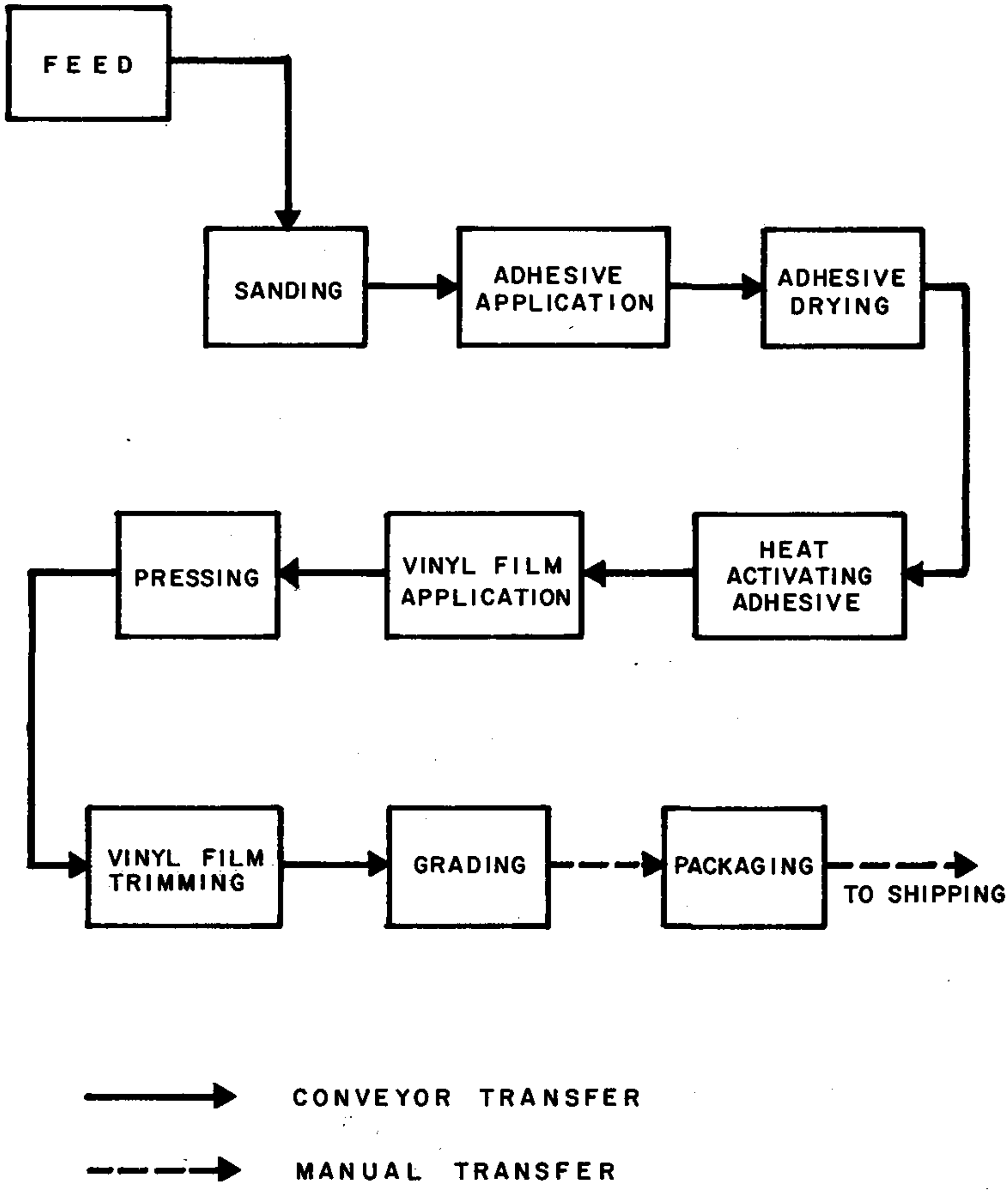


FIGURE 22 PROCESS FLOW DIAGRAM FOR VINYL FILM OVERLAYING

SECTION IV

INDUSTRY CATEGORIZATION

In the development of effluent limitation guidelines and standards of performance for the timber products industry, it was necessary to determine the differences which may form a basis for subcategorization of the industry. The rationale for subcategorization was based on differences and/or similarities in the following factors: (1) quality and quantity of waste waters produced, (2) the engineering feasibility of treatment and the resulting effluent reduction, (3) plant age, (4) plant size, (5) raw materials used, (6) manufacturing process employed, and, (7) the costs of treatment and control.

Effluent guidelines limitations and standards of performance for the barking, veneer, plywood, hardboard and wood preserving portion of the timber products processing industry were published as 40 CFR Part 429, subparts A through H. This regulation appeared in the Federal Register, Volume 39, 13942 (April 18, 1974).

A previous study by the Midwest Research Institute for EPA concerning pollution from silvicultural activities discussed timber harvesting. Therefore, while various aspects of timber harvesting may be subject to future guidelines, this portion of the timber product industry is not studied nor subjected to effluent limitation guidelines in this document. Also not subject to recommended effluent guidelines in this document are (1) the storage of logs in waters other than self-contained ponds, (2) the transportation of logs in water, (3) the storage of lumber and other end products, (4) dry decking of logs, and (5) storm water runoff from yards and roofs. In Section V, waste water characteristics will be discussed for the storage of logs in waters other than ponds. In Section VII, management techniques for the reduction of pollution will be discussed for transportation and storage of logs in waters other than ponds, storage of lumber and other end products, dry decking, and storm water runoff.

As outlined in the description of the industry in Section III, the timber products industry consists of many different manufacturing processes. Several factors affecting quality and/or quantity of waste produced, the engineering feasibility of treatment and resulting effluent reduction, and the cost of treatment were considered significant with regard to identifying potential subcategories for these processes. The factors considered included: (1) process employed, and variations, (2) nature of raw materials, (3) plant size and age, (4) land availability, (5) climatic relationships, and (6) process water requirements.

In consideration of the above factors, the segment of the timber products industry included in this study and subject to proposed effluent limitations has been subcategorized as follows:

(1) Wet storage,
(2) Log washing,
(3) Sawmills,
(4) Finishing,
(5) Particleboard manufacturing,
(6) Insulation board manufacturing, and
(7) Insulation board manufacturing with steaming or hardboard production.

The rationale for the above categorization is as follows:

Process Variation

The production of products from wood and wood by-products, as indicated in Section III, involves considerable variation in process operations. These variations, whether caused by the end product desired, raw materials used, processing method used, or other factors, can result in considerably different waste water characteristics, applicable control and treatment alternatives, and costs of control and treatment alternatives. Of all factors considered, process variation is the most significant in determining possible subcategorization. The possible subcategories resulting from consideration of this factor are:

(1) Wet storage in water
(2) Wet storage on land
(3) Dry storage
(4) Fabricating operations in which mechanical fasteners or non-water soluble adhesives are used
(5) Fabricating operations in which water soluble adhesives are employed
(6) Finishing operations employing water soluble materials
(7) Finishing operations employing non-water soluble materials
(8) Log washing
(9) Sawmills and planing mills
(10) Insulation board production employing little or no steaming of raw furnish
(11) Insulation board production employing extensive steaming and having no hardboard production, or employing limited steaming with hardboard production
(12) Insulation board production empoying steaming and having hardboard production
(13) Particleboard production

Ponds as discussed Section III, are distinct process variations in that logs may remain in a log pond for long periods of time or for periods of time seldom exceeding a week.

Land storage of logs or other raw materials is distinct from water storage in that the waste water generation from land storage results from spraying water on the logs or from precipitation runoff while the pollution associated with water storage results from the leaching of substances directly into the water. Furthermore, except in the case of sprayed land decks without recycle, the flow produced by land storage is dependent on sufficient rainfall while the flow from storage ponds may be continuous, at least on a seasonal basis.

However, information regarding the treatment and control reliabilities, and the waste water characteristics variabilities, is limited. It is not feasible to subcategorize the storage of logs to a more specific level than wet storage.

The processes involved in fabrication result in a highly concentrated glue waste. In some cases these wastes may be similar to the glue wastes produced by plywood manufacturing while in other cases they are quite different, depending on the type resin used.

Those process variations which employ mechanical fasteners generate no waste water. Those employing organic soluble resins, while requiring cleanup of equipment generate a volume of water sufficiently small that it can be contained and reused. Those operations employing water soluble resins constitute the majority of the fabricating industry and generate a volume of waste water sufficiently large that treatment and disposal is necessary.

The unit process of finishing produces a unique waste water requiring special handling and treatment. The waste water primarily consists of various concentrations, depending on the amount of wash water used, of paint and other finishing materials. The characteristics of the waste water vary widely, depending on the ingredients used in the finishing substances. A substantial variation occurs, however, depending on whether water soluble or non-water soluble materials are used.

Another process variation that results in a different waste water stream is the unit operation of log washing. Log washing does not result in the same degree of leaching effects that occur in ponds because of the short contact time of the water with the log and results in an effluent with a considerably higher grit content than the effluents from other timber products operations. Because of the different waste water characteristics resulting from log washing, the unit process is considered to be a separate subcategory.

Sawmills and planing mills are considered a separate subcategory in that the processes employed may require the use of water, but with proper control no discharge of waste water pollutants is achievable.

In the production of boards the process of insulation board manufacturing and particleboard manufacturing have definite differences, as described in Section III, and result in waste waters that require different control and treatment technologies.

While the production of insulation board products from wood involves similar operational procedures in any plant, considerable process variation can and does occur. These variations may be caused by the end product desired or by the practices and procedures of plant management. There are two process variations which produce significant differences with regard to waste water generation in the insulation board industry. These variations involve the effect of steaming or not steaming raw material before refining and whether or not a plant produces hardboard products. Although waste water flows and solids concentrations will vary little between subcategories, BOD, will vary considerably. When steaming is done prior to the refining there is a release of soluble organics that are not released when no steaming is done. This in terms of BOD loading approximately doubles the waste load. The effect of producing hardboard products is that hardboard products require additives of a different nature than plants producing insulation board products. Also there is more refining of the wood necessary for the production of hardboard type products. These will be discussed in more detail in Section V, Water Use and Waste Characterization.

Because of significant differences in waste water loads, the insulation board industry has been further divided into two subcategories: plants that do not steam their raw furnish, and plants that steam their raw furnish or produce hardboard products.

The production of particleboard involves similar operational procedures in all plants; however, there are process variations that can occur. These variations do not affect waste water flows or concentrations considerably. The biggest variation derives from the production differences inherent between those plants producing extruded particleboard, and those that produce mat-formed particleboard.

While extruded particleboard accounts for less than one percent of the total production and plants are much smaller, the reported daily waste water flows vary little from the largest mat-formed particleboard plant because the components of the waste water essentially are the same. Process variations are not considered as a technical element necessitating subcategorization and because of no significant differences in water usage, the particleboard industry has not been divided into further subcategories.

Nature of Raw Materials

No subcategorization resulted from consideration of the nature of raw materials. It would be expected that species type would have an effect on the characteristics of waste waters from timber products operations, particularly those in which an appreciable source of pollutants is the leachates from wood and wood products. However, as shown in Section V, Water Use and Waste Characterization waste water characteristics do not show sufficient differences to warrant further subcategorization based on species type.

A more significant effect is produced by whether the raw material is in the form of fractionalized wood or whole logs. As shown in Section V, whole log storage in wet or dry decks produces significantly different waste water characteristics from piles of chips, planer shavings, bark, and other similar materials.

While approximately 30 percent of all insulation board plants utilize mineral wool as a portion of their raw material, it was found that this practice did not cause sufficient variations in waste water loads to warrant subcategorization. One insulation board plant uses bagasse as its sole raw material. All particleboard plants utilize wood as a raw material. Although the raw material may be in the form of roundwood, chips, planer shavings, or sawdust, a significant variation in waste water loads with variation in raw materials was not found. Because a major waste stream from a plant comes from the washing of the additive blending areas, a difference in additives will affect the waste water quality. However, this is not considered to be an effect significant enough to warrant further subcategorization.

Plant Size and Age

Operations in the timber products industry range in size from "backyard" businesses to complexes with thousands of employees. In most cases size of operation and waste water volume and pollutant load will be proportional and thus, on a basis, size has a negligible effect on waste water characteristics.

In addition, cost of control and treatment technology tends toward a constant factor on a unit product basis. In larger operations, economy of scale is applicable to various degrees but, while this must be given consideration, it does not in itself justify subcategorization of the industry. On the other extreme, small operations have treatment and disposal options such as retention, land spreading, and trucking to landfill, that are impractical on larger scales. These factors are taken into account in the development of control and treatment alternatives in Section VII, but do not constitute a basis for subcategorization of the industry.

Plant age cannot be considered as a basis for subcategorization because operations vary in age of equipment as well as structures, i.e., plants generally undergo a continuous modernization of facilities and the actual "age" of an installation is indeterminable. Furthermore, the age of equipment does not necessarily affect waste water generation. More important factors are operation and maintenance of the equipment.

The only trend related to age observed in this study is that of particleboard plants in the western U. S. tending to be of more recent origin than those in the East. However, as indicated in Section V, no differences in waste water generation could be discerned for the two groups.

Nature of Water Supply

The quantity and quality of fresh water supplies utilized by timber products operations were originally considered to be possible elements for industry subcategorization because of potential prohibitive factors that could be encountered in control and treatment. However, despite the fact that the industry tends to use the most available water supplies and a wide variation in the nature of the water supplies result, no detectable effects on control and treatment have resulted from this study. Therefore, nature of water supply is not regarded as a technical element necessitating subcategorization.

Plant Location and Land Availability

The location of a timber products plant may be significant in terms of climatic effects on operations and control and treatment technology, the availability of adequate land for the construction of treatment facilities, and other factors. These factors have received consideration in the development of control and treatment technology (Section VII) in which, for example, various evaporation rates were considered for different sections of the country and different treatment alternatives were developed for varying amounts of available land.

Despite the fact that plant location and land availability can affect the practicality of various control and treatment methods as well as costs, no rational subcategorization can be based on this consideration because of the wide variability of conditions. The considerations taken in the development of control and treatment technology are considered adequate for the development of effluent limitations guidelines and plant location and land availability are rejected as technical elements necessitating subcategorization.

Water Usage

Several operations in the timber products industry experience a unique usage of water. These are the storage of logs in estuaries, rivers, and impoundments, and the transportation of logs in water. The water pollution generated by these operations is unique in that no waste water streams are produced; the pollution results from direct contact of the operations with surface water bodies. Any attempts to characterize the pollutional effects result in water quality considerations, and, while certain management techniques as discussed in this document can be effective in reducing pollution, no treatment technology is applicable to these operations. Therefore, as a result of the nature of water usage, the operations of log storage in estuaries, rivers, and impoundments, and the transportation of logs in water are considered as a separate subcategory of the timber products processing industry. However, as previously stated, these operations are not subject to effluent limitations at this time.

SUMMARY OF SUBCATEGORIZATION

The segments of the timber products processing industry considered in this document have been separated into the following subcategories for the purpose of proposing effluent limitations guidelines and new source performance standards. These subcategories are defined as:

1. Wet Storage. The wet storage subcategory includes the holding of unprocessed wood, before or after bark removal, i.e., logs, in self-contained bodies of water (ponds) or land storage of unprocessed wood where water is sprayed on the wood. This operation is commonly referred to as wet decking.

2. Log Washing. The log washing subcategory refers to the process of passing the wood raw material through an operation where water under pressure is applied to the log for the purpose of removing foreign material from the surface of the log before further processing.

3. Sawmills and Planing Mills. The sawmills subcategory includes timber products processing operations of sawing, resawing, edging, trimming, planing and/or machining.

4. Finishing. The finishing subcategory includes operations that follow edging, trimming and planing. These operations include drying, dipping, staining, and coating, moisture proofing and by-product utilization not otherwise covered by effluent limitations guidelines and standards.

5. Particleboard. The particleboard manufacturing subcategory includes the manufacture of particleboard. Particle board is defined as board products that are composed mainly of distinct particles of wood or other ligno-cellulosic materials not reduced to fibers which are bonded othether with an organic or inorganic binder. (A component of particleboard furnish may be fibrous material.)

6. Insulation board. The insulation board manufacturing subcategory includes facilities that produce a fiberboard from wood in a fibrous state. The board has a density of less than 0.5 g/cu cm (31 lb/cu ft). The manufacturing process involved does not involve

subjecting the wood material to a pressure created by steam.

7. Insulation board Manufacturing with Steaming or Hardboard Production. This subcategory includes the manufacture of insulation board at facilities that either steam condition the raw material before refining or that produce hardboard at the same facility.

SECTION V

WATER USE AND WASTE CHARACTERIZATION

Water is used in various ways throughout the timber products processing industry and a variety of waste waters result. This section describes the water usage and characterizes the waste waters associated with the subcategories identified in Section IV. For each subcategory discussed herein, a model is developed.

It should be noted that the water usage and waste water characteristics described for each operation, unless otherwise specified, are descriptive of that particular operation. Various unit operations may be employed in conjunction with other operations and the resulting waste water characteristics are essentially a weighted average of those of the unit operations. For example, prior to the fabrication of wirebound crates, a veneering operation may be involved. The veneering operation, in turn, could have associated with it bark removal operations and log pond storage. The waste stream resulting from the complex would be a combination of the waste streams from each of the unit operations.

A model operation is developed below for each of the operations or combinations of operations discussed in Sections III and IV of this document. As discussed earlier, the variety of operations conducted in this segment of the timber products processing industry are numerous. Consideration of the process water volume requirements, the process waste water quality, and the practicability of reuse and disposal techniques results in the conclusion that so called model operations can be described, not specific to each and every variation included in this portion, but applicable to the operations being considered in this document. This approach is appropriate to the purpose of developing the control and treatment technologies (Section VII) and the presentation of cost information (Section VIII).

STORAGE OF LOGS IN ESTUARIES, IMPOUNDMENTS, RIVERS, AND TRANSPORTATION OF LOGS IN WATER

The quantity of materials contributed to the water by logs in open water storage and transportation is dependent on the leaching rate of substances from the logs which in turn is dependent on such factors as the residence time of logs in water, log species, and quality of water. For example, in a laboratory study, Graham and Schaumburg showed that the leaching of pollutants from logs is rapid initially but decreases with time. They also showed that more pollutants were leached from Ponderosa pine than Douglas fir logs and that more pollutants are leached from logs suspended in fresh water than from those suspended in saline waters.

Log storage in open waters occurs primarily in the northwestern U. S. The primary concern about such storage has involved the aesthetics of floating bark. Several investigations have been addressed to the problem of bark loss and its eventual deposition site. The results of the studies all point to the fact that most of the dislodging of bark from logs occurs at the dump site where the violent entry into the water is accompanied by the abrasive action of the logs rubbing against one another. The logs are usually allowed to free-fall into the water from distances ranging from a meter or so up to six or more meters, the greater falls occuring when dumping into tidal waters is done at low tide.

The work at Oregon State University by Graham under the direction of Schaumburg on the leaching of pollutants from logs has led to the formulation of equations characterizing the leaching. The equation originating from the work of Graham and Schaumburg with modification by Williamson and Schaumburg is of the form:

$$T = (1-x)\ (D)\ (Ac) + (x)\ (C)\ (Ac) + f1\ (B-D)\ Ae$$

where:

T = total pollutional contribution from field logs (grams)

$$B = \frac{\text{grams leached from test log (ends unaltered, w/bark)}}{\text{sq m of cylindrical area}}$$

$$C = \frac{\text{grams leached from test log (ends sealed, w/bark)}}{\text{sq m of cylindrical area}}$$

$$D = \frac{\text{grams leached from test log (ends sealed, w/o bark)}}{\text{sq m of cylindrical area}}$$

Ae = total submerged end area of field logs (sq m)

Ac = total submerged cylindrical area of field logs (sqm)

x = fraction of bark missing from field logs

$$f1 = \frac{\text{cylindrical area of test log}}{\text{end area of test log}}$$

Typical calculations using this equation for a 20 hectare (50 acre) raft of Ponderosa pine that has a free flowing water profile and a log storage time of 30 days, yield a COD combination of 320 kg/day (700 lb/day) and a BOD contribution of 150 kg/day (320 lb/day).

Similar calculations performed for logs stored on a fresh water reservoir with a volume of about 2.4×10^5 cu m (8.7×10^6 cu ft) and an average flow of 79.1 cu m/min (46.5 cfs) yield an average detention time of 52 hours. Ten measurements of water quality were made over a three day period of both the influent and effluent from the reservoir. The average value and the standard deviation for each of the measured parameters are shown in Table 10. The calculated results are also shown. It can be seen from this study that the expected and observed changes in water quality through the reservoirs are extremely small in terms of concentration. It can also be seen that the predicted change is always less than the observed change. This is probably because of the fact that the equation does not take into account the contribution of the benthic deposits to the water quality.

TABLE 10 BOD, COD, PBI AND TOC IN INFLOW AND OUTFLOW FROM LOG STORAGE RESERVOIR NUMBER 74

Pollution Index	Inflow Mean Concentration mg/1	Outflow Mean Concentration mg/1	Measured Increase		Predicted Increase	
			mg/1	kg/day[2]	mg/1	kg/day
BOD	0.25 ± 0.13	1.25 ± 0.55	1.0	110	0.02	2
COD	8.7 ± 3.7	10.0 ± 4.1	1.3	150	0.07	8
PBI[1]	1.6 ± 0.83	1.8 ± 0.54	0.2	20	0.16	18
TOC	3.7 ± 0.95	3.9 ± 1.87	0.2	120	0.03	4

[1]PBI -Pearl Benson Index is expressed as ppm SSL - Spent Sulfite Liquor (10% by weight)

[2]kg/day based on a flow of 79.1 cu m/min (30mgd)

In addition, the variability of the measured parameters is such that the standard deviation is nearly half the value of the parameters for all measured parameters. Limited field applicability of the equation is, therefore, indicated. Similar results are reported by Williamson and Schaumburg for other impoundments studied. The evaluation of the equation by Williamson and Schaumburg when applied to estuarine analyses showed that the maximum change in any of the water quality parameters studied would be less than 1.0 mg/l. Consequently, field studies were not conducted in this study because it was surmised that the variability of the water quality resulting from tidal recycles would far exceed these differences.

Samples were collected in this study in both the Little Deschutes River and the Deschutes River in Oregon above and below log impoundments. The results of the analyses of these samples showed that it was virtually impossible by water quality measurements to determine the degradation in water caused by the logs. Some of the downstream samples were higher than the upstream samples and some were lower, but in both cases the measurable effect was too low to be considered significant. This observation agreed with the work of Williamson and Shaumburg.

The waters above and below four large log rafts were measured on estuaries at Astoria, and at Goose Bay. Three of the four rafts sampled showed that the concentration of pollutants increased from the downstream end of the raft to the upstream end, while the third raft sampled showed an increase in concentration in the expected direction, from upstream to downstream. Two samples collected on the Columbia River at Longview, Washington, showed the same reverse trend. No attempt was made to determine the variability of the measured parameters because of the magnitude of the sampling that would have been required.

The data collected by Williamson and Schaumburg and also that collected in this study illustrate that it is not possible to readily determine the change in water quality of an impoundment because of log storage on the impoundment. Without that capability, it is not possible to reliably predict or measure the pollutional contribution of the logs to the storage waters. The effect of easy let-down devices in reducing the amount of floating bark released to the water is evident from visual observations, but no further studies were performed to quantitatively evaluate this. No typical waste water can be characterized because it is not currently possible to reliably measure a waste water characteristic that can be attributed solely to the logs in the water.

Wet Storage

The following discussion is divided into three portions, identified as mill ponds, log ponds and wet decking. The division, particularly mill ponds and log ponds, may be considered somewhat artificial. However, this division provides an opportunity to discuss potential differences in water use and waste characterization.

MILL PONDS

Mill ponds are those man-made water impoundments used primarily for sorting logs and feeding them into a plant. Mill ponds are usually less than one ha (2.5 ac) in size and usually are typified by low flow rates and short log residence time.

Two of the four ponds reported in a study by Haufbur are typical mill ponds (Table 11). Ponds C and D are small ponds and the average storage time is two weeks and one week, respectively. The relatively high flow of 25 lps (400 gpm) through pond C causes low concentrations of pollutants, whereas the lower flow of one liter per second (16 gpm) through pond D causes higher concentrations of pollutants. Pond B in Table 11 would qualify as a mill pond because of the short residence time of the logs and because of the high concentration of pollutants, even though the pond is 8 ha (20 ac) in size. There would have to be an intense amount of activity occurring on a 8 ha (20 ac) pond in order to exchange 80 percent of the logs in one week. Pond A is a typical log pond, in that the area of the pond is large and the storage time in the pond is long. Because there is no outflow, the concentration of pollutants is not as low as Pond C, but not nearly as high as Pond B and D.

Another typical pond is that identified as Pond 04 (Table 12). It is only about one ha (2.5 ac) in size and the detention time of logs in the pond is only about three hours. The activity on the pond is sufficiently high that suspended solids of 579 mg/l are reported. Other parameters such as COD and BOD are low because the high flow rate washes the pollutants from the pond.

McHugh, Miller, and Olson collected a large quantity of water quality data while studying mosquitoes in log ponds. Some of those data are listed in Table 13 along with the areas of the log ponds as supplied by the Oregon Department of Ecology. In addition, data supplied from various sources are list in Table 13.

Grab samples were collected during this study from several ponds in Oregon and Washington and analyzed for several parameters. Based on the distinctions mentioned above, some of these ponds were classified as mill ponds and the values of the measured parameters are listed in Table 14.

TABLE 11
LOG POND DATA

Physical Characteristics of Log Ponds Studied

Pond	Surface Area Hectares	Average Depth, Meters	Age of Pond, Years	Type of Logs Stored	Length of Storage	Water Source	Remarks
A	10.5	2.4	11	Douglas fir	1-3 yrs.	Stream	Non-overflowing except during high runoff periods. Sanitary wastes dumped into pond.
B	8.1	1.8-2.4	14	Douglas fir	80% of logs about one week	Wells	Non-overflowing except during high runoff periods. Sanitary and glue wastes from plywood plant dumped into pond.
C	1	3.7	19	85% Ponderosa pine 15% Douglas fir	Two weeks	Stream	Overflowing at about 25 l/sec.
D	1.2	1.2-1.5	39	Over 90% Ponderosa pine	One week	Springs: irrigation ditch	Overflowing at about .0 l/sec.

TABLE 11
LOG POND DATA (Cont'd)

Chemical Characteristics of Log Ponds Studied
Pond A

Point	TS, mg/l a/	VS %	SS, mg/l	DO, mg/l	Temp, °C	pH	COD, mg/l	BOD20, mg/l	BOD5 mg/l	BOD5/COD	k, day-1	N, b/ mg/l	NO3-N, c/ mg/l	PO4, mg/l	PBI mg/l
1	254	59	43	0.1	22	6.9	116	48	29	0.25	0.08	2.4	0.6	0.5	175
2	253	53	38	0.1	22		116								
3	230	49	27	0.4	22		104								
4	238	53	134	0.2	22		116								
4-B	391	46	21				100								
5	260	56	35	0.2	22		116								

a/ mg/l = milligrams per liter = ppm

b/ N - total kjeldahl nitrogen (ammonia plus organic nitrogen)

c/ NO3-N = nitrate nitrogen

4-B = bottom sample taken at point 4

TABLE 11
LOG POND DATA (Cont'd)

Pond B

Point	TS, mg/l	VS %	SS, mg/l	DO, mg/l	Temp, °C	pH	COD, mg/l	BOD20 mg/l	BOD5, mg/l	BOD5/COD	k, day-	N, mg/l	NO3-N, mg/l	PO4, mg/l	PBI, mg/l
1	747	55	180	0.3	21.5	7.1	496	167	54	0.11	0.03	110.4	1.5	11.2	545
2	724	63	162	0.2	21.5	7.1	484								
3-B	776	60	266	0.0	21		504								
4	720	61	234	0.2	22		488								
5	723	57	248	0.3	22		488								
6	755	56	256	0.1	22		504								

3-B = bottom sample taken at point 3

TABLE 11
LOG POND DATA (Cont'd)

Pond C

Point	TS mg/l	VS %	SS, mg/l	DO, mg/l	Temp, °C	pH	COD mg/l	BOD20 mg/l	BOD5, mg/l	BOD5 / COD	k, day^{-1}	N, mg/l	NO3-N, mg/l	PO4, mg/l	PBI mg/l
1	352	30	d	1.5	23		20								
2	356	31	d	1.7	23	7.5	24	10	6	0.25	0.08	1	0.1	0.1	35
3	360	32	d	2.0	23		26								
4	352	30	4				22								

dFrozen samples--suspended solids tests not run

Pond D

Point	TS mg/l	VS %	SS, mg/l	DO, mg/l	Temp, °C	pH	COD, mg/l	BOD20, mg/l	BOD5, mg/l	BOD5 / COD	k, day^{-1}	N, mg/l	NO3-N, mg/l	PO4, mg/l	PBI mg/l
1	550	40	d	0.4	21		312								
2-B	580	50	d	0.2	20.5		316								
3	530	44	d	0.5	21		3 0								
4	606	46	122	0.7	21.5	7.4	353	116	68	0.19	0.08	4.9	0.7	2.0	338

2-B = bottom sample taken at point 2

TABLE 12

WINTER CHARACTERISTICS OF OREGON LOG PONDS*

PART B: PHYSICAL CHARACTERISTICS (Cont'd)

Pond	Surface Area (Hectares)	Average Depth (Meters)	Volume (Cu.M)	Type of Log	Log Detention	Water Source	Remarks and Approximate Eff.
01	23	1.4	314,912	65% Doug. fir	60 Days		Overflow in Nov. to Mar. = about 1,635 Cu. M/Day
02	17	1.2	207,039	100% Doug. fir	126 Days	Another Pond	Overflow in Nov. to Mar. = about 1,643 Cu.M/Day
03	23	1.5	345,192	65% Doug. fir 35% Hemlock	44 Days	Reservoir	Overflow in Nov. to Mar. = about 1,635 Cu. M/Day
04	1.2	1.8	22,937	40% Doug. fir 60% Hemlock	3 hours	Creek	Impounded creek overflowing Nov. to Mar. = about 489,000 Cu. M/Day

*Based on Environmental Science and Engineering, Inc. sampling from March 2 to March 6, 1973.

TABLE 12
WINTER CHARACTERISTICS OF OREGON LOG POND*
PART A: CHEMICAL CHARACTERISTICS

Pond	BOD_5	COD	DS	SS	TS	Turb.	Phenols	Color	Kjld-N	$T\text{-}PO_4\text{-}P$
01	2	47	69	11	80	8	0.03	14	1.40	0.02
02	3	67	130	21	151	6	0.01	9	1.33	0.02
03	5	57	81	31	112	12	0.03	18	2.30	0.02
04	10	64	90	579	669	40	0.03	9	0.34	0.02
06	7	46	120	42	162	28	0.08	12	2.82	0.025
48	3	78	271	26	297	4	0.06	13	0.45	0.02

Note: Turbidity in JTU: color in Pt.-Cobalt units; all others in mg/l.

*Based on Environmental Science and Engineering, Inc. sampling from March 2 to March 6, 1973.

TABLE 13
LITERATBRE DATA FOR PONDS

Pond	Date		Temp.	D.O.	Color	Turb.	BOD	COD	PO_4T	NTOT	BOD/COD	TOTS	TOTSS	Area
03	40073	-	-	-	18.0	12.0	5.0	57.0	0.02	2.30	0.09	-	-	57.00
04	40073	-	-	-	9.0	40.0	10.0	64.0	0.02	0.34	0.16	-	-	3.00
02	40073	-	-	-	9.0	6.0	3.0	67.0	0.02	1.33	0.04	-	-	42.00
01	40073	-	-	-	14.0	8.0	2.0	47.0	0.02	1.40	0.04	-	-	57.00
05	40073	-	-	-	23.0	18.0	336.0	957.0	0.05	0.05	0.35	-	-	-
06	40073	-	-	-	13.0	26.0	6.0	65.0	0.02	1.82	0.09	-	-	-
07	70072	6.9	22.0	0.1	-	-	29.0	116.0	0.50	2.40	0.25	-	-	26.00
08	70072	7.1	21.5	0.3	-	-	54.0	504.0	1.20	10.40	0.11	-	-	20.00
09	70072	7.5	23.0	1.5	-	-	6.0	24.0	0.10	1.00	0.25	-	-	2.50
10	70072	7.4	21.5	0.7	-	-	68.0	353.0	2.00	4.90	0.19	-	-	3.00
11	62860	6.5	-	-	62.0	7.0	-	43.0	0.03	0.13	-	47.0	-	6.00
12	64	5.0	-	-	100.0	44.0	-	417.0	0.18	7.67	-	391.0	-	0.50
13	64	6.5	-	-	100.0	7.0	-	93.0	0.12	9.60	-	290.0	-	-
14	64	5.8	-	-	100.0	11.0	-	351.0	0.37	5.50	-	347.0	-	0.70
15	64	6.9	-	-	75.0	8.0	-	121.0	0.06	5.40	-	261.0	-	1.00
16	64	6.8	-	-	75.0	20.0	-	105.0	0.18	-	-	291.0	-	0.75
17	64	7.1	-	-	125.0	10.0	-	80.0	0.24	-	-	257.0	-	3.00
18	64	7.4	-	-	25.0	6.0	-	48.0	0.10	5.10	-	234.0	-	3.00
19	64	7.1	-	-	25.0	7.0	-	52.0	0.02	6.04	-	300.0	-	1.50
20	64	6.9	-	-	25.0	8.0	-	42.0	0.02	2.68	-	85.0	-	-
21	64	7.0	-	-	150.0	16.0	-	68.0	0.06	3.22	-	138.0	-	-
22	64	5.8	-	-	125.0	32.0	-	161.0	0.29	0.21	-	222.0	-	-
23	64	6.4	-	-	100.0	34.0	-	200.0	3.36	11.62	-	320.0	-	1.50
24	64	6.4	-	-	25.0	7.0	-	11.0	0.0	-	-	33.0	-	0.74
25	64	6.4	-	-	50.0	7.0	-	40.0	0.06	0.19	-	76.0	-	1.00
26	64	5.5	-	-	50.0	50.0	-	422.0	0.84	4.57	-	506.0	-	0.60
27	64	7.4	-	-	50.0	9.0	-	31.0	0.14	0.22	-	117.0	-	2.50
28	64	4.9	-	-	50.0	42.0	-	681.0	0.60	9.95	-	658.0	-	0.50
29	64	6.7	-	-	50.0	12.0	-	209.0	0.44	-	-	340.0	-	1.00
30	64	6.9	-	-	150.0	19.0	-	300.0	0.0	-	-	502.0	-	2.50
31	64	6.3	-	-	500.0	10.0	-	434.0	0.01	-	-	481.0	-	2.00
32	64	6.3	-	-	100.0	10.0	-	62.0	0.0	0.95	-	116.0	-	-
33	64	6.4	-	-	50.0	9.0	-	9.0	0.04	-	-	82.0	-	0.70
34	64	6.2	-	-	50.0	14.5	-	144.0	0.10	16.10	-	260.0	-	-
35	64	7.0	-	-	50.0	9.0	-	83.0	0.04	7.01	-	345.0	-	5.00
36	64	6.2	-	-	25.0	8.0	-	67.0	0.0	-	-	102.0	-	0.50
37	64	5.3	-	-	150.0	23.0	-	676.0	0.49	10.58	-	422.0	-	4.00
38	64	6.2	-	-	25.0	7.0	-	52.0	1.02	-	-	123.0	-	-
39	64	4.8	-	-	100.0	24.0	-	713.0	0.50	8.86	-	255.0	-	0.60
40	64	6.3	-	-	50.0	12.0	-	144.0	2.66	7.30	-	237.0	-	2.50
41	64	7.3	-	-	40.0	7.0	-	47.0	0.05	-	-	247.0	-	1.50
42	64	9.5	-	-	20.0	4.0	-	11.0	0.0	-	-	116.0	-	0.30
43	64	5.9	-	-	150.0	23.0	-	187.0	0.15	3.55	-	244.0	-	2.00
44	64	6.7	-	-	200.0	40.0	-	600.0	3.00	-	-	669.0	-	1.00
45	64	7.8	-	-	40.0	8.0	-	82.0	3.00	-	-	417.0	-	0.70
46	64	7.0	-	-	15.0	8.0	-	21.0	0.37	2.59	-	393.0	-	-
47	64	6.1	-	-	100.0	50.0	-	228.0	0.77	0.48	-	455.0	-	0.50
48	64	7.0	-	-	50.0	12.0	-	4.0	0.06	4.51	-	97.0	-	100.00
49	64	6.7	-	-	30.0	8.0	-	21.0	0.10	-	-	76.0	-	0.10
50	64	6.3	-	-	200.0	56.0	-	173.0	0.41	1.90	-	473.0	-	1.50
51	64	7.8	-	-	100.0	8.0	-	117.0	0.14	-	-	185.0	-	4.00
52	64	5.8	-	-	50.0	8.0	-	106.0	0.10	5.44	-	146.0	-	-
53	64	6.0	-	-	200.0	160.0	-	431.0	0.0	9.19	-	1055.0	-	0.70
54	64	6.5	-	-	25.0	16.0	-	112.0	-	4.32	-	130.0	-	0.25
55	64	5.5	-	-	50.0	14.0	-	202.0	-	-	-	268.0	-	-
56	64	5.8	-	-	50.0	56.0	-	802.0	0.76	8.57	-	805.0	-	1.50
57	64	6.2	-	-	200.0	7.0	-	84.0	0.24	-	-	150.0	-	0.30
58	64	6.6	-	-	-	-	-	204.0	0.15	3.05	-	-	-	4.00
59	64	7.4	-	-	175.0	43.0	-	-	0.76	-	-	23876.0	-	-
60	64	6.0	-	-	50.0	6.0	-	37.0	0.29	2.61	-	74.0	-	6.00
61	64	6.3	-	-	25.0	8.0	-	15.0	0.0	0.17	-	60.0	-	0.50
62	64	6.4	-	-	20.0	6.5	-	38.0	0.10	0.22	-	82.0	-	0.25
63	64	6.5	-	-	50.0	25.0	-	225.0	0.01	1.49	-	2097.0	-	0.50
64	64	6.6	-	-	25.0	7.0	-	22.0	0.08	0.38	-	68.0	-	0.50
65	64	6.3	-	-	50.0	6.0	-	37.0	0.10	0.64	-	66.0	-	-
66	64	5.6	-	-	150.0	7.0	-	188.0	0.0	4.00	-	154.0	-	-
67	50873	6.5	-	-	-	60.0	26.0	164.0	0.04	0.12	0.16	222.0	95.0	-
68	52173	6.4	-	-	-	90.0	46.0	118.0	0.03	0.08	0.39	225.0	71.0	-
69	21373	7.1	37.0	3.7	120.0	112.0	34.0	-	-	-	-	-	88.0	-
70	21373	7.1	38.0	1.4	75.0	76.0	17.0	-	-	-	-	-	23.0	-
69	22073	6.4	52.0	2.6	220.0	28.0	41.0	-	-	-	-	-	-	-
70	22073	6.4	56.0	1.8	140.0	26.0	29.0	-	-	-	-	-	-	-
69	22773	6.0	44.0	1.3	200.0	26.0	19.0	-	-	-	-	-	-	-
70	22773	6.2	52.0	0.0	120.0	22.0	24.0	-	-	-	-	-	-	-
69	30673	6.3	44.0	1.5	200.0	38.0	31.0	-	-	-	-	-	72.0	-
70	30673	6.6	43.0	0.1	120.0	21.0	20.0	-	-	-	-	-	35.0	-
69	31373	6.3	46.0	2.1	220.0	92.0	39.0	-	-	-	-	-	60.0	-
70	31373	6.4	45.0	0.5	140.0	34.0	36.0	-	-	-	-	-	3.0	-
69	32073	6.3	48.0	0.0	200.0	39.0	37.0	-	-	-	-	-	35.0	-
70	32073	6.6	51.0	1.8	140.0	15.0	22.0	-	-	-	-	-	35.0	-
69	32773	7.6	51.0	0.0	130.0	74.0	48.0	-	-	-	-	-	49.0	-
70	32773	6.9	50.0	0.0	150.0	62.0	46.0	-	-	-	-	-	89.0	-
69	40373	6.5	50.0	0.0	100.0	520.0	20.0	-	-	-	-	-	64.0	-
70	40373	6.5	53.0	0.5	150.0	570.0	27.0	-	-	-	-	-	79.0	-
69	41073	6.2	53.0	0.0	100.0	155.0	23.0	-	-	-	-	-	42.0	-
70	41073	6.3	58.0	3.7	100.0	128.0	20.0	-	-	-	-	-	-	-
69	41773	6.6	52.0	0.9	140.0	84.0	29.0	-	-	-	-	-	21.0	-
70	41773	6.7	53.0	1.0	120.0	80.0	19.0	-	-	-	-	-	12.0	-
69	42473	6.2	54.0	0.0	100.0	360.0	24.0		-	-	-	-	35.0	-
70	42473	6.5	60.0	-	125.0	230.0	23.0	-	-	-		-	94.0	-
69	50173	7.2	57.0	3.4	120.0	34.0	20.0	-	-	-		-	-	-
70	50173	8.2	64.0	-	160.0	23.0	27.0	-	-	-		-	-	-
69	50873	6.3	58.0	0.0	100.0	68.0	21.0	-	-	-		-	35.0	-
70	50873	6.4	58.0	0.9	120.0	76.0	24.0	-	-	-		-	29.0	-
69	51573	6.4	64.0	0.0	300.0	255.0	24.0	-	-	-		-	26.0	-
70	51573	7.1	76.0	5.8	300.0	190.0	19.0	-	-	-		-	26.0	-
69	60573	6.6	49.0	0.0	175.0	114.0	18.0	-	-	-		-	19.0	-
70	60573	6.9	71.0	0.0	175.0	84.0	41.0	-	-	-		-	25.0	-
69	71073	6.1	73.0	-	450.0	150.0	17.0	-	-	-		-	32.0	-
70	71073	6.2	77.0	-	250.0	130.0	11.0	-	-	-		-	16.0	-
69	91973	-	-	-	-	-	-	107.0	2.20	0.60		-	-	-

TABLE 14
CHARACTERIZATION OF MILL PONDS

Pond	Color	Turbidity	BOD_5	COD	PO_4	N_T	TS	SS	TDS	TVS	VSS	VDS	Phenols	Water Flow (Cu m/day)	Production (Cu m/day)[16]	Pond Area (Hectares)
44	86	20	59	98	2.0	1.95	429	8	421	112	0	112	39.3	6,170	0.39	1.2
44	124	67	55.9	84.5	3.45	1.86	448	30	418	141	11	130	--	6,170	0.39	1.2
72	433	36	66	221.2	5.44	4.91	446	199	247	216	129	87	98.7	0	0.65	0.2
28	171	4	44	53	1.80	2.42	153	31	121	70	25	45	9.4	0	0.06	1.2
04	9	40	10	64	0.02	0.34	669	579	40	-	-	-	22.0	488,265	0.63	0.2
23	571	15	50	301	6.49	5.54	350	68	282	258	37	221	5.4	0	0.42	1.2
23	476	9	40	262	7.18	4.57	298	66	232	194	142	152	11.4	0	0.42	0.2
73	117	304	-	121.6	1.84	2.18	138	103	35	75	52	23	2.6		0.37	1.2

Several observed trends have been previously noted in making the distinction between log ponds and mill ponds. These include the small pond size and the great amount of activity on the mill pond as compared to the log pond. Chemical parameters tend to support this distinction as shown in Tables 11, 12, and 13, in that total solids, COD, BOD, nitrogen, and phosphate concentrations in the mill pond tend to be higher than those in the log ponds. Regression analysis was conducted for selected parameters for the ponds of less than one ha (three ac) in Table 13 and for the six ponds in Table 14. The correlation coefficient (r), the slope (m), and the intercept (b) of the line of best fit for the linear regression analysis are shown in Table 15. More than 40 data points were used in all the regressions from Table 13 with the exception of the COD-BOD relation where only 11 observations were available. The parameters for which significant correlation occurred were COD-TS (r-0.854) and COD-BOC (r-0.838). This should be contrasted to the data analysis for the six ponds listed in Table 15, Part B.

The parameters that did not correlate well are COD-TS (r=0.036), COD-Turb (r=0.113), COD-SS (r=0.231), and the correlation of BOD with COD and Kjeldahl nitrogen. It was felt that the data collected by McHugh, et al, while adequate for the purpose for which it was collected, was not applicable to a determination of which ponds should be in which category. Also, it was not possible to discern if the data were reliable for the intensive data analysis that was required in this study. In addition, it should be noted that the data set used to generate Table 15, Part A, was taken from ponds in which the hydraulic flow was known for only a few of the ponds, and the area of the ponds were known only for those ponds listed in Table 13. For these reasons, the data in Table 15, Part B, was considered to be a more reliable representation of mill ponds than the data in Part A of the same table. The condition of the water in the mill ponds appears to be a function of the pond size, the activity on the pond, and the water flow through the pond.

The draft report, which is the basis for the proposed guidelines and standards which this document supports further developed the relationships of log loading across the pond, hydraulic loading across the pond, and area of the pond to suggest a chemical oxygen demand in mg/l. This relationship is based on data developed from many sources, including surveys conducted during this study.

Because the regulations being proposed at this time do not include limitations on biological parameters, the equation that suggests that relationship is not presented here. Interested parties are referred to the contractors draft report, published December, 1973.

The good correlations of most of the parameters in Table 15 with COD, and the good correlation of COD with the physical parameters of the pond as per the equation, indicate that those parameters in solution listed in Table 14 are all readily related directly

TABLE 15
DATA CORRELATIONS FOR MILL PONDS

PART A (McHugh, *et al.* Data)

Independent Variable	Dependent Variable	r*	m	b
COD	NT	0.487	0.0102	2.936
COD	Color	0.355	0.1479	59.112
COD	PO4	0.224	0.00105	0.3536
COD	TS	0.854	0.7922	121.556
COD	Turbidity	0.527	0.0668	7.756
PO4	NT	0.641	2.9715	3.147
BOD	NT	0.620	0.0777	0.6507
COD	BOD	0.838	0.1307	4.416
PART B (Six Ponds, This Study)				
COD	NT	0.901	0.0179	0.316
COD	Color	0.935	2.063	-59.94
COD	PO4	0.943	0.0259	-0.487
COD	TS	-0.036	-0.078	372.38
COD	Turbidity	-0.113	-0.139	92.77
PO4	NT	0.964	0.697	0.633
BOD	NT	0.687	0.0651	0.0245
COD	BOD	0.433	0.090	31.782
COD	SS	-0.231	-0.530	239.97

Dependent Variable = (m) (Independent Variable) + b to the physical parameters of the pond. The fact that the suspended fraction of the mill pond waters does not correlate well with any of the soluble parameters indicates that the suspended fraction is not related to the activity on the pond in the same fashion as the soluble fraction. It was not possible to obtain a good correlation of the suspended fraction with any rational combination of the physical parameters. This may indicate that the suspended fraction is highly dependent on the specific conditions existing in the particular pond with respect to the amount that the bottom gravel and muds are agitated, while the soluble fraction is primarily a function of the amount of materials leaching directly from the logs.

The poor correlation of BOD and COD concentrations further evidences the low reliability that should be placed on BOD for materials leached from woods and barks. The highly variable behavior of the BOD/COD ratio for uncooked leachates was evidenced throughout the study.

The characteristics of the effluent from a mill pond, in the event that there is a discharge, is highly dependent on the number of logs going across the pond per unit time and is less dependent on the area and hydraulic flow through the pond. There is often a discharge from the mill pond because of the function of the mill pond in the timber products industry. The mill pond is used to feed the logs into the mill, and usually to sort the logs before they go to the mills. Because most mill machinery is set up to accomodate only a small water level fluctuation, it is necessary to maintain the pond near full or completely full throughout the year. For this reason, even a non-flowing pond will overflow during a period of natural precipitation. Some of the ponds are allowed to overflow continually, but with greater overflow occurring during periods of precipitation. During periods of low precipitation, water is added to the pond to make up for evaporative losses. Hence, the mill pond is always full and the discharge may be continuous or intermittent.

It is difficult to describe a single waste stream, or even a waste stream that is characteristic of a mill pond. Consequently, the data in Table 16 are for a hypothetical mill pond representative of a mill pond with a moderate flow and log loading, and a large area.

LOG PONDS

Several laboratory studies have been performed prior to this study, but have limited value in discussing log ponds. However, the data developed in the studies are valuable in establishing trends that can be expected for pollutants in log ponds. One that is particularly applicable is the study conducted by Graham on the leaching of pollutants from logs submerged in tanks with suppressed biological activity. The study showed that COD, TOC, PBI, and TVS of the water increased at a rapid rate initially and then tended to reach a maximum concentration at detention times greater than 40 days. In addition, it was observed that if the

TABLE 16
TYPCIAL WASTE STREAM FROM A MILL POND

Parameter	Value
Hydraulic flow, cu m/day	3,800
Log loading, cu m/day	115
Area, hectares	1.2
Calculated Parameters	
COD (mg/l)	68
Color (units)	80
NT	1.53
PO4	1.27
Estimated Parameters	
BOD5 (mg/l)	14
Turbidity (JTU)	20
Total Solids (mg/l)	250
Suspended Solids (mg/l)	50

log that had been leached to an apparent maximum concentration in the surrounding water was then removed from that water and then placed in fresh water, the concentration of leachates increased in the fresh water in a fashion similar to that in the original water. This indicated that the leaching rate of materials from the log is a function of the concentration of the leached materials in the surrounding waters. It was also found that the bark inhibits the initial loss of soluble organic matter from the logs and contributes most of the color producing substances. It was also found that Ponderosa pine logs contribute higher concentrations of leachates than Douglas Fir logs.

In a study by Benedict, bark was submerged in water and the concentration of leachates in the water was measured with time. Just as in the log study, maximum concentrations were reached after 40 to 60 days, but the concentration of leachates was considerably higher. The age of the bark was found to be an important variable, i.e., the older bark yielded less leachates than the younger. Similar work by Asano and Towlerton involved the study of leachates from submerged wood chips. Once again, the plateau value of concentration was obtained, but after only 20 to 30 hours of agitation of the sample. The concentration of leachates in the surrounding water was found to be dependent on the concentration of wood chips in the water. The color of the supporting water was found to increase to 3,000 to 4,000 standard color units, whereas the color of the water surrounding the bark in the Benedict study was found to increase to 7,000 to 8,000 units. This is in support of the observations by Graham that most of the color from the logs came from the bark. A different study by Spoul and Sharpe on bark tends to support the observations in the three previously mentioned studies, but the experimental conditions were different and direct comparison is not possible.

Pond A listed in Table 11 is a good example of a log pond and, even though Pond B is large enough to conform to the area associated with the log ponds, the number of logs that move across the pond per day is so high that Pond B should be classified as a mill pond. The listing of literature data in Table 13 shows that only eight of the ponds in the list have areas large enough to be classified as log ponds. Two of these ponds are the same as Pond A and B listed in Table 11, one of which is not a log pond even though its size is substantial. Three of the ponds were sampled only once in the winter and two of the ponds were sampled only once in the summer. Only one pond was sampled more than once and the data were rather incomplete. For these reasons, it was determined that a more comprehensive study should be performed on log ponds in order that adequate characterization could result.

Three log ponds were selected for study. The selection was based on the size and physical characteristics of the ponds, and the fact that previous data had been collected on these particular ponds. Log Pond 01 (Figure 23) was chosen because there is no mill or plant on its shores or discharging into it. Log Pond 02

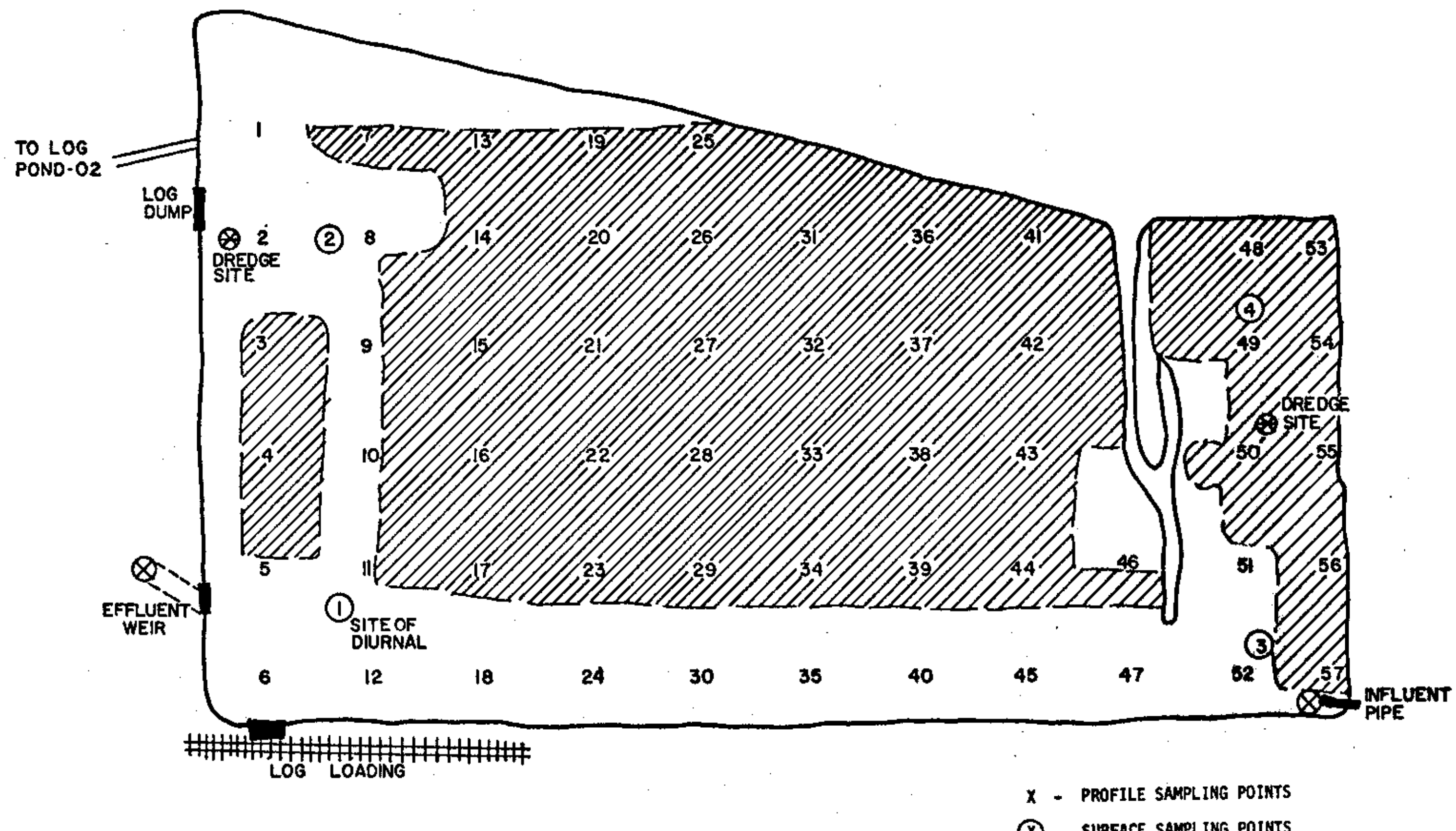
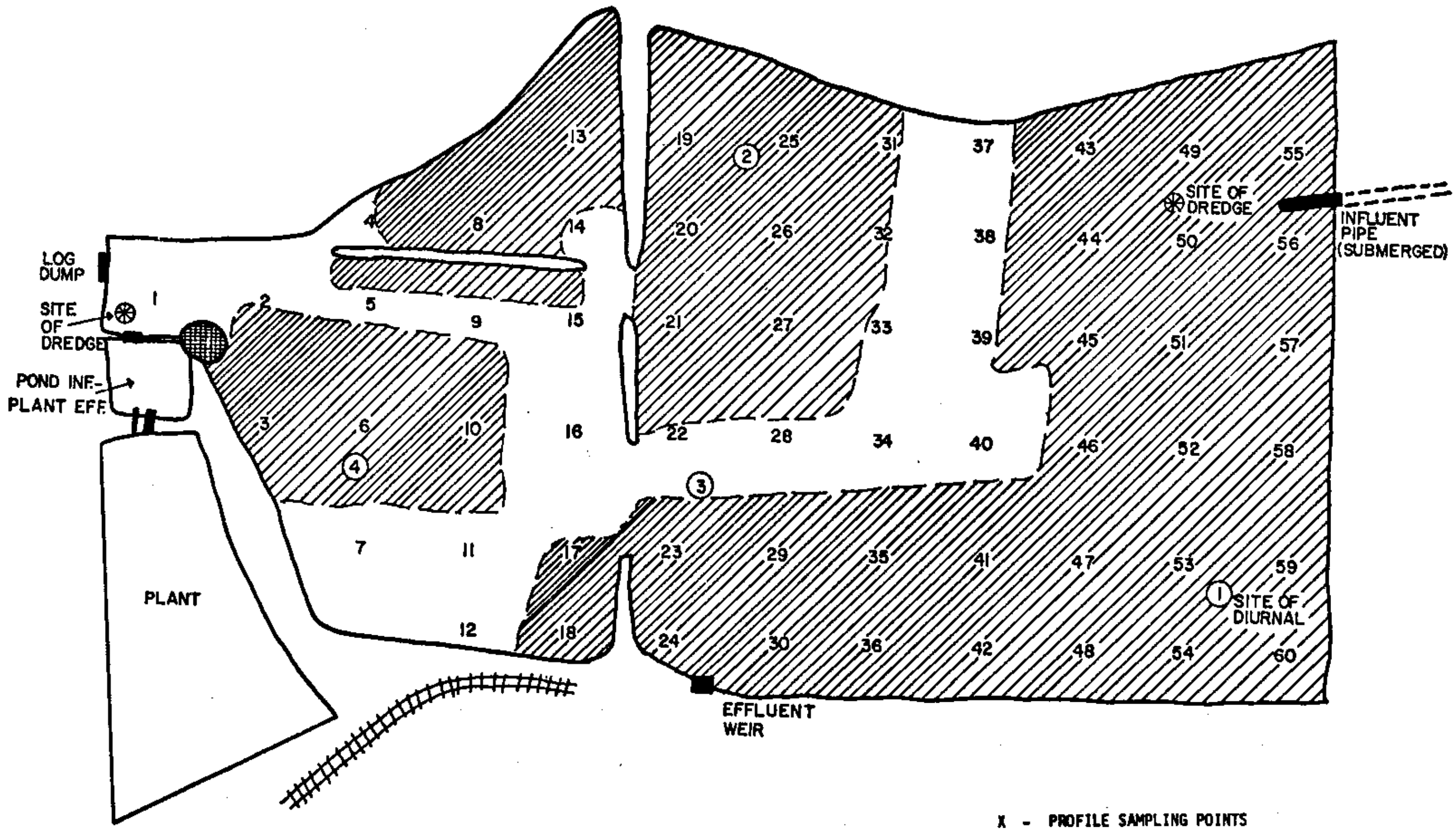


FIGURE 23 LOG POND 01



X - PROFILE SAMPLING POINTS

(X) - SURFACE SAMPLING POINTS

FIGURE 24 LOG POND 02

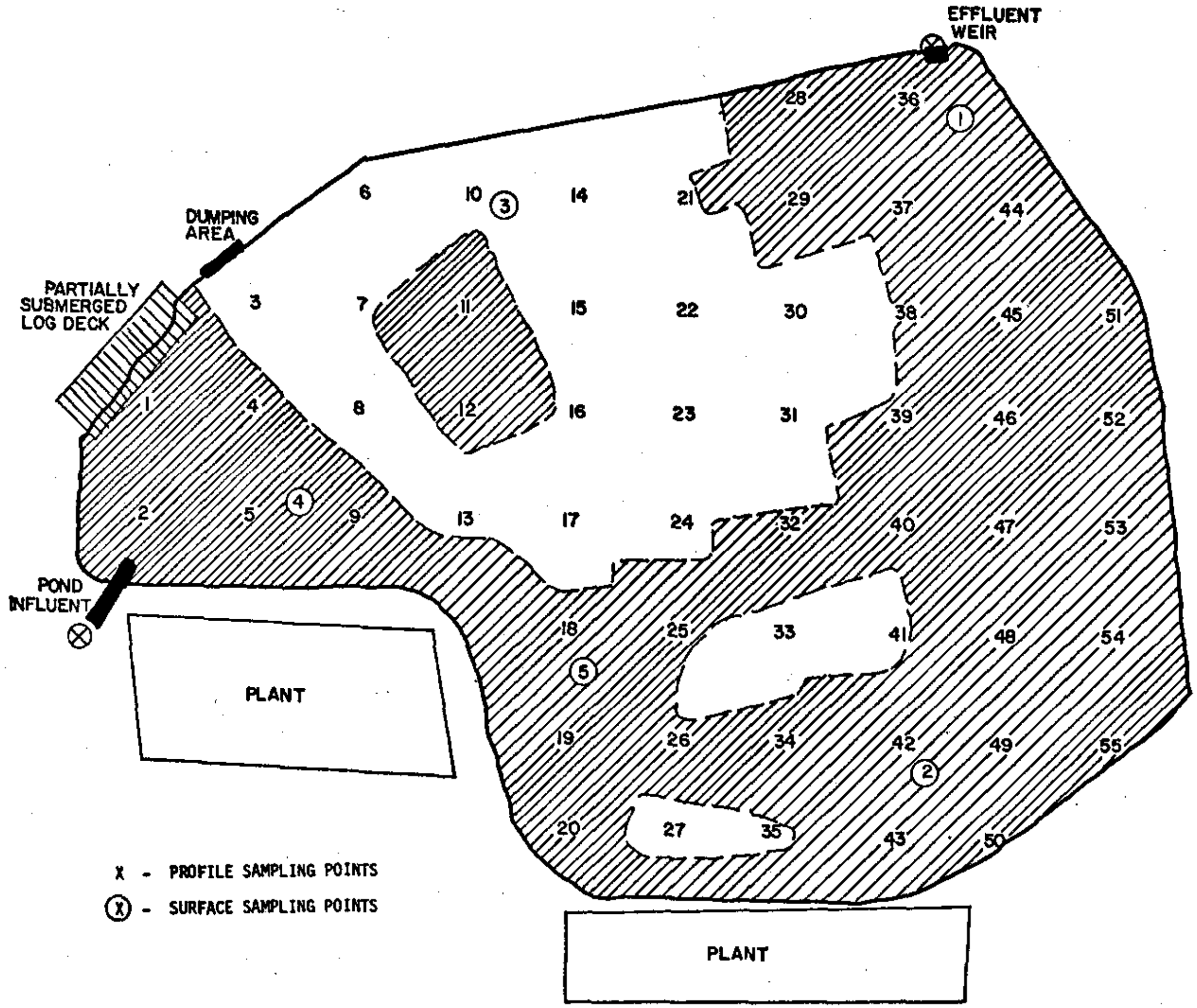


FIGURE 25 LOG POND 03

TABLE 17
AVERAGE VALUE AND 95 PERCENT CONFIDENCE
INTERVAL FOR VARIOUS PARAMETERS FOR LOG
POND 01

	COLOR	TURB.	BOD_5	COD	PO_4	N_T	TS	TSS	TDS	TVS	TVSS	TVDS	PHENOLS
Influent (N = 5)	11.59±5.58	1.58±1.13	5.98±7.43	13.8±7.44	0.59±0.28	3.75±5.58	46.39±31.88	27±28.89	19.4±6.7	20.60±14.09	11.40±11.74	9.20±10.56	12.32±7.40
Effluent Week 1 (N = 14)	121.35±2.14	3.57±0.43	18.68±3.00	58.95±5.76	1.01±0.25	4.03±2.25	113.5±27.9	32.5±13.3	81.0±23.5	60.57±13.74	15.86±7.44	44.71±9.92	16.18±8.09
Effluent Week 2 (N = 7)	122.70±7.90	4.43±1.39	19.04±11.57	57.8±2.5	0.92±0.29	1.91±0.39	151.57±77.33	33.14±25.47	119.28±67.50	77.86±18.77	14.28±12.01	64.71±16.91	10.91±7.22
Effluent Week 3 (N = 3)	103.66±24.53	4±4.99	22.13±29.35	56.73±5.77	1.04±0.56	1.91±0.69	77±13.17	10.6±27.3	66.3±10.1	62.3±23.8	2.60±5.16	59.6±21.13	10.89±5.73
Effluent Total (N = 24)	120.38±4.37	3.88±0.50	19.22±3.52	56.89±3.46	0.99±0.17	3.15±1.32	120.04±25.78	29.96±9.99	90.33±20.79	65.83±9.43	13.79±5.30	52.42±7.76	13.57±4.73

TABLE 18
AVERAGE VALUE AND 95 PERCENT CONFIDENCE
INTERVAL FOR VARIOUS PARAMETERS FOR LOG
POND 02

	COLOR	TURBIDITY	BOD_5	COD	PO_4	N_T	TS	TSS	TDS	TVS	TVSS	TVDS	PHENOLS
Influent (N = 4)	135.75±23.96	13±3.91	23.17±3.50	108.92±22.02	1.52±0.57	2.73±0.54	271.5±93.84	58±69.88	188.5±41.3	104.75±40.28	23.25±40.09	81.5±15.24	18.80±31.23
Effluent Week 1 (N = 14)	144.5±31.77	8.57±1.12	28.58±9.96	96.21±6.11	1.25±0.43	4.69±2.48	223.43±16.44	36.78±18.25	186±22.27	101.78±11.94	19.5±11.9	82.28±12.98	24.70±12.33
Effluent Week 2 (N = 7)	138.14±9.20	10.43±1.91	21.34±9.32	86.88±4.18	1.09±0.12	2.59±0.49	269.86±89.49	45.71±48.4	223.86±59.49	107.28±33.38	22.86±25.99	84.43±20.11	9.33±6.91
Effluent Week 3 (N = 3)	115±11.4	7.66±1.46	19.30±6.28	88.43±10.37	1.17±0.39	2.38±0.47	215.33±77.63	31.67±91.22	183.67±17.47	118.33±92.0	25.33±92.47	89.67±11.23	16.90±12.45
Effluent Total (N = 24)	138.96±18.08	9±0.85	25.31±6.14	92.10±5.01	1.19±0.25	3.77±1.43	235.58±25.06	38.75±15.93	196.75±20.01	105.46±11.40	21.21±10.10	83.83±8.63	19.00±7.42

TABLE 19
AVERAGE VALUE AND 95 PERCENT CONFIDENCE INTERVAL FOR VARIOUS PARAMETERS FOR LOG POND 03

	COLOR	TURB.	BOD_5	COD	PO_4	N_T	TS	TSS	TDS	TVS	TVSS	TVDS	PHENOLS
Influent (N = 3)	3.33± 7.19 -3.86- 10.52	0.29±0.43 -0.14-0.72	9.27±18.42 -9.15-27.69	7.73± 8.99 -1.26-16.72	0.54±0.69 -0.15-1.23	1.49±0.52 0.97-2.01	33.33± 31.28 2.05- 64.61	14.33±34.85 -20.52-49.18	19.00± 13.17 5.83- 32.17	19.67± 14.85 4.82- 34.52	7.33±22.98 -15.65-30.31	12.67± 15.02 -2.35- 27.69	9.89± 9.78 0.11-19.67
Effluent, Week 1 (N = 14)	357.71± 72.30 285.41-430.01	5.00±0.78 4.22-5.78	33.01± 7.95 25.06-40.96	134.43± 3.54 130.89-137.97	1.66±0.43 1.23-2.09	5.64±2.66 2.98-8.30	149.14± 24.13 125.01-173.27	38.36±22.77 15.59-61.13	112.21± 11.08 101.13-123.29	105.14± 14.75 90.39-119.89	27.14±14.80 12.34-41.94	78.00± 13.02 64.98- 91.02	37.48±19.25 18.23-56.73
Effluent Week 2 (N = 7)	344.57± 9.23 335.34-353.80	5.57±0.73 4.84-6.30	35.53±35.07 0.46-70.60	127.74± 24.84 102.90-152.58	1.22±0.39 0.83-1.61	3.04±0.20 2.84-3.24	143.86± 31.96 111.90-175.82	39.00±39.25 - 0.25-78.25	104.86± 18.65 86.21-123.51	109.43± 12.28 97.15-121.71	24.00±21.00 3.00-45.00	85.43± 16.71 68.72-102.14	8.43± 5.49 2.94-13.92
Effluent Week 3 (N = 3)	321.0 ± 58.52 262.48-379.52	4.33±3.79 0.54-8.12	22.10± 6.88 15.22-28.98	126.20± 31.11 95.09-157.31	1.82±0.65 1.17-2.47	2.81±0.04 2.77-2.85	130.33± 27.97 102.36-158.30	24.00±46.09 -22.09-70.09	106.33± 20.27 86.06-126.6	106.33± 41.05 65.28-147.38	18.33±41.78 -23.45-60.11	88.00± 2.50 85.50- 90.50	27.07±62.82 35.75-89.89
Effluent Total	357.62± 35.69 321.93-393.31	5.09±35.69 4.57- 5.61	32.37± 9.46 22.91-4.83	133.40± 6.46 126.94-139.86	1.55±0.27 1.28-1.82	4.50±1.57 2.93-6.07	145.29± 15.50 129.79-160.79	36.75±15.81 20.94-52.56	109.33± 7.70 101.63-117.03	106.54± 8.88 97.66-115.42	25.13± 9.81 15.32-34.94	81.42± 8.34 73.08- 89.76	28.55±12.85 15.70-41.40

TABLE 20
SURFACE SAMPLE ANALYSES FOR LOG PONDS 01

Surface No.	Sample No.	pH	Temp. °F	DO	Color	Turb	BOD5	COD	PO4	NT	TS	TSS	TDS	TVS	TVSS	TVDS	Phenols
	23	6.2	17	1.5	143	5	14.0	56.6	0.09	4.48	85	5	70	70	16	54	5.0
	89	5.9	17	1.4	119	4	24.5	53.2	0.99	1.88	126	0	16	70	2	68	13.7
	138	6.0	19	0.8	94	7	20.0	59.4	1.10	1.92	83	28	55	55	1	54	19.6
	Average	6.0	18	1.2	119	5	19.5	56.4	1.06	2.76	98	18	80	65	6	59	12.8
2	24	5.9	17	1.6	130	6	16.0	63.8	1.26	4.71	110	54	56	72	44	28	4.4
	90	5.7	17	1.5	121	3	22.0	57.4	0.98	2.21	116	35	81	78	34	44	14.4
	139	5.9	23	1.7	198	6	17.0	55.4	1.04	1.76	73	20	53	62	0	62	12.9
	Average	5.8	19	1.6	116	5	18.3	58.9	1.09	2.89	100	36	63	71	26	45	10.6
3	21	6.3	17	1.4	128	5	25.5	52.5	1.38	3.26	78	6	72	63	3	60	12.7
	91	5.8	20	2.5	124	5	19.5	54.6	0.92	2.03	23	13	110	42	0	32	18.1
	136	6.4	30	5.9	90	4	18.0	57.4	1.31	2.32	87	17	70	67	2	65	12.3
	Average	6.2	22	3.3	114	5	21.0	54.8	1.20	2.54	96	12	84	57	5	52	11.0
4	22	6.3	16	1.8	131	8	18.8	68.7	1.30	3.96	83	23	60	78	17	61	18.5
	92	5.7	18	1.9	124	4	3 .5	61.4	1.20	2.46	90	12	78	64	5	59	15.6
	137	5.9	22	0.8	195	4	20.5	65.3	1.23	2.32	91	21	70	73	3	70	18.5
	Average	6.0	19	1.5	117	5	23.6	65.1	1.24	2.91	88	19	69	72	8	63	14.2

TABLE 21

SURFACE SAMPLE ANALYSIS FOR LOG POND 03

Surface No.	Sample No.	pH	Temp °F	DO	Color	Turb	BOD5	COD	PO4	NT	TS	TSS	TDS	TVS	TVSS	TVDS	Phenols
1	31	6.4	20	2.3	135	8	22.0	92.9	0.83	2.72	232	36	196	107	22	85	41.7
	112	6.2	24	4.0	119	7	37.8	79.6	0.88	2.80	187	49	138	71	37	34	11.7
	128	6.2	21	1.3	113	6	18.0	93.1	1.29	2.38	203	13	190	140	11	129	22.9
	Average	6.3	22	2.5	122	7	25.9	88.5	1.00	2.63	207	33	175	106	23	83	25.4
2	35	6.8	19	1.8	124	7	23.0	95.0	0.91	2.93	222	29	193	60	20	40	28.9
	114	6.3	20	3.9	119	7	44.1	79.5	1.37	2.52	188	65	123	64	54	10	13.3
	133	6.4	23	1.2	106	6	23.7	196.0	1.07	2.06	198	35	163	103	5	98	4.8
	Average	6.5	21	2.3	116	7	30.3	123.5	1.12	2.50	203	43	161	76	26	49	15.7
3	33	6.8	19	1.8	124	7	23.0	95.0	0.85	2.43	222	29	193	60	20	40	13.9
	113	6.0	18	1.4	133	12	40.1	82.3	1.21	2.32	194	82	112	78	51	27	5.6
	129	6.3	18	0.9	107	12	19.2	95.0	1.29	3.51	199	11	188	112	9	103	30.6
	Average	6.4	18	1.4	121	10	27.4	90.8	1.12	2.75	205	41	164	83	27	57	16.7
4	36	6.9	24	3.1	138	10	22.4	90.9	1.02	2.20	217	14	203	45	8	37	24.2
	115	6.3	22	2.0	131	11	39.1	82.3	0.91	2.28	191	33	158	88	32	56	9.6
	132	6.1	22	0.5	114	12	21.7	131.5	1.34	2.84	212	19	193	99	1	98	11.9
	Average	6.4	23	1.9	128	11	27.7	101.6	1.09	2.44	207	22	185	77	14	64	15.2

TABLE 22

SURFACE SAMPLE ANALYSIS FOR LOG POND 03

Surface No.	Sample No.	pH	Temp °F	DO	Color	Turb	BOD5	COD	PO4	NT	TS	TSS	TDS	TVS	TVSS	TVDS	Phenols
1	44	5.9	20	1.4	343	5	26.5	135.3	0.99	3.26	150	85	65	92	30	62	31.1
	79	5.9	19	1.3	340	5	23.5	117.2	1.26	3.14	241	171	70	161	121	40	9.2
	147	5.4	23	1.0	342	3	23.8	118.8	1.81	3.40	182	72	110	155	60	95	17.5
	Average	5.7	21	1.2	342	4	24.6	123.8	1.38	3.27	191	109	82	136	70	66	19.3
2	48	5.9	24	1.4	333	6	19.5	133.3	0.93	2.43	145	12	133	97	7	90	26.7
	84	5.8	19	1.5	365	6	21.5	124.0	0.96	3.41	245	163	82	135	62	73	17.5
	148	5.6	26	1.2	338	2	16.5	118.8	1.86	3.17	162	40	122	142	21	121	11.0
	Average	5.8	23	1.4	345	5	19.2	125.4	1.25	3.00	184	72	112	125	30	95	18.4
3	45	5.9	26	2.1	348	5	28.5	135.3	0.92	2.77	96	28	68	56	8	48	23.3
	80	5.9	22	1.9	375	8	22.0	119.2	1.17	2.56	161	10	151	126	7	119	5.2
	149	5.5	22	0.5	342	3	17.0	122.8	1.49	3.07	155	28	127	133	28	107	18.7
	Average	5.8	23	1.5	355	5	22.5	225.8	1.19	2.80	137	22	115	105	14	91	15.7
4	46	5.9	25	1.5	381	8	22.0	135.2	0.81	2.72	197	17	180	77	12	65	14.4
	83	5.8	23	1.4	365	6	29.0	120.0	1.44	2.86	120	25	195	99	22	77	19.0
	150	5.8	25	0.4	324	2	17.0	122.8	1.59	3.37	187	20	167	108	7	101	19.8
	Average	5.8	24	1.1	357	5	22.7	126.0	1.28	2.98	168	21	147	195	14	81	17.7
5	47	5.9	23	1.4	381	7	22.5	127.2	0.92	2.58	160	10	150	115	2	113	25.3
	82	5.9	20	1.5	375	6	21.5	124.0	1.17	2.46	151	53	98	98	23	75	18.1
	151	5.7	25	1.2	343	2	15.5	120.8	1.51	3.11	155	58	97	121	54	67	16.7
	Average	5.8	23	1.4	366	5	19.8	124.0	1.20	2.72	155	40	115	111	26	85	20.0

TABLE 23
WINTER DATA FOR LOG PONDS 01, 02, AND 03

Pond	Date	Color	Turbidity	BOD_5	COD	PO_4	N_T	TS	TSS	TDS	TVS	TVSS	TVDS	Phenols
01														
202	110673	120	6	20.0	63.5	1.6	1.83	90	45	45	78	38	40	0
205	110673	138	6	13.0	61.9	3.5	1.80	97	35	62	76	24	52	0
208	110773	138	5	20.0	66.6	2.9	1.68	63	8	55	60	8	52	0
211	110773	123	7	14.4	62.3	3.2	2.53	96	13	83	59	2	57	139.4
214	110873	123	5	20.0	61.2	1.1	2.54	135	35	100	75	31	44	42.3
218	110973	109	4	5.0	60.0	0.9	0.79	76	4	72	54	0	54	20.5
222	111273	105	5	10.0	63.1	2.0	1.09	63	5	58	25	4	21	22.4
Average Values		122	5	15.0	62.7	2.2	1.75	89	21	68	61	15	46	32.1
02														
203	110673	136	12	23.0	109.0	1.2	2.18	225	62	163	115	52	63	6.9
206	110673	148	10	23.0	103.9	3.0	1.96	231	28	203	116	12	103	2.3
209	110773	140	11	23.6	113.7	2.5	2.46	202	18	184	86	0	86	0
212	110773	143	14	29.4	105.8	1.4	3.68	235	68	167	102	50	52	50.6
215	110873	141	6	4.5	91.3	1.3	1.88	168	10	158	98	8	90	32.4
219	110973	118	8	8.0	102.7	0.7	1.32	215	32	183	79	6	73	31.8
223	111273	121	10	24.0	110.5	1.4	1.57	201	19	182	88	12	76	13.7
Average Values		135	8	19.4	105.7	1.6	2.15	211	34	177	98	20	78	19.6
03														
201	110673	295	8	17.0	110.9	4.8	4.10	120	47	73	83	33	50	1.7
204	110673	319	16	24.0	107.8	4.8	2.73	138	50	88	100	40	60	2.0
207	110773	314	6	15.0	109.8	3.8	2.58	93	1	92	90	0	90	0
210	110773	302	6	26.6	109.4	6.0	2.88	140	26	114	90	7	83	87.3
213	110873	296	5	10.0	109.8	2.1	2.98	136	42	94	89	18	71	56.1
217	110973	286	4	15.0	107.4	1.8	1.69	113	19	94	88	12	76	35.2
224	111273	290	4	20.0	109.1	4.0	1.30	95	5	90	72	1	71	16.0
Average Values		300	7	18.2	109.2	4.5	2.61	119	27	92	87	[illegible]	76	28.0

Observed Flows: Pond 01 - 4.6 Cu M/Min
Pond 02 - 7.1 Cu M/Min
Pond 03 - 15.6 Cu M/Min

TABLE 24

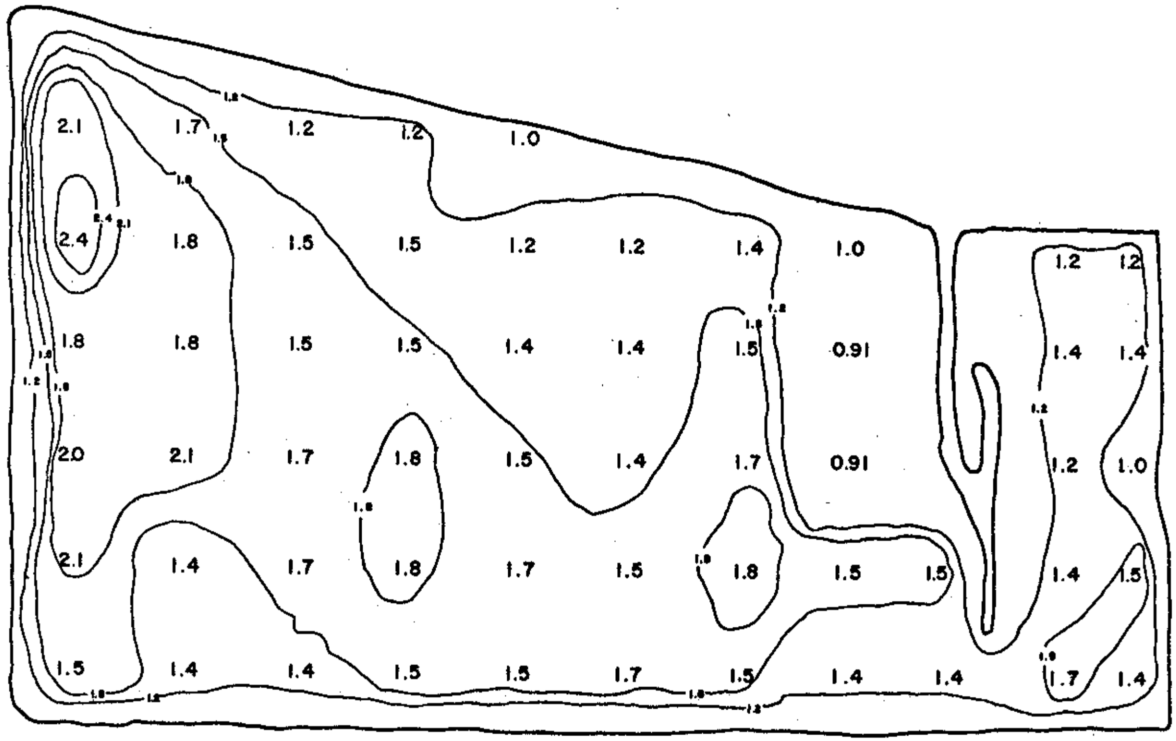
DIURNAL STUDY ON LOG PONDS 01 AND 02

Pond	Location	Ph	Temp.	DO	Color	Turbidity	BOD_5	COD	PO_4	N_T	Total Solids	Total Suspended Solids	Total Dissolved Solids	Total Volatile Solids	Total Volatile Suspended Solids	Total Volatile Dissolved Solids	Phenols mg/l	Depth Sampling Point
01 Pond-AM	Surface	5.8	16°	.9	117	4	27.5	51.5	2.05	1.91	75	9	66	56	0	56	6.0	-
	Middle	5.8	16°	.7	119	4	23.4	51.5	1.80	2.17	85	13	72	77	2	75	2.3	1.7m
	Bottom	5.8	15°	.5	119	5	24.5	53.4	1.17	2.30	65	3	62	49	0	49	2.3	-
01 Pond-PM	Surface	6.0	17°	1.7	133	5	25.0	54.9	.91	2.14	90	28	62	82	25	57	41.7	-
	Middle	5.9	16°	1.5	126	7	16.6	54.9	1.09	1.54	75	3	67	67	0	67	13.3	-
	Bottom	5.9	15°	1.3	126	6	22.0	54.1	1.02	1.74	83	23	60	51	12	39	92.5	-
02 Pond-AM	Surface	6.1	17°	1.0	114	6	23.0	87.1	1.20	2.46	186	16	170	96	7	89	4.6	-
	Middle	6.0	17°	.7	114	6	29.5	92.1	1.06	2.37	186	9	177	79	2	77	2.3	-
	Bottom	6.0	17°	.6	126	9	27.0	84.3	1.11	2.37	183	2	181	90	2	88	3.7	2.3m
02 Pond-PM	Surface	6.2	23°	1.9	124	5	29.0	85.4	1.00	2.21	198	15	183	79	10	69	20.0	-
	Middle	6.0	17°	1.0	131	10	26.0	98.0	1.13	2.43	316	141	175	121	28	93	15.4	-
	Bottom	6.0	17°	.7	131	9-	31.0	86.2	1.23	1.66	248	93	155	98	36	62	6.2	-

TABLE 25

DATA FROM LOG PONDS IN THE WASHINGTON OREGON, IDAHO AREA LOG PONDS

Pond	pH	Temp.	Color	Turbidity	BOD5	COD	PO4	NT	TS	TSS	TDS	TVS	TVSS	TVDS	Phenols	Area (Hectares)
71	-	-	29	0	7.5	29.7	.90	.87	67	0	67	38	1	38	0.0	70
19	-	-	276	26	-	233.2	11.18	7.12	446	53	393	163	0	163	39.3	6
72	-	-	21	5	21.5	13.7	2.00	3.98	95	8	87	20	0	20	0.0	22
69	6.15	75°F	350	140	14.0	107.0	2.20	0.60	-	24	-	-	-	-	0.01	93
01	-	-	109	2	13.2	43.1	.40	3.15	112	3	71	45	43	43	-	49.9
02	-	-	138	9	25.3	92.1	1.19	3.77	236	39	196	105	21	84	-	52.2
03	-	-	354	5	23.1	125.7	1.01	3.01	74	22	90	87	18	69	-	48.9

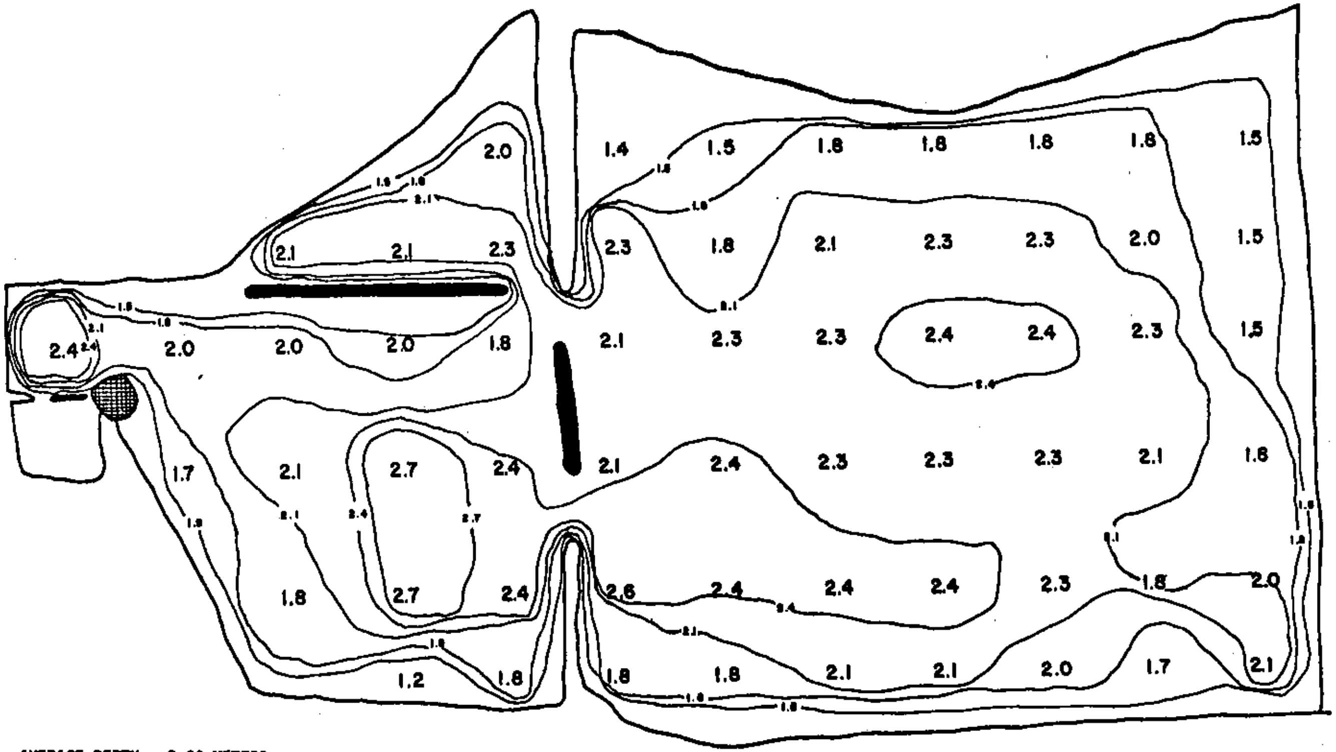


AVERAGE DEPTH - 1.51 METERS

VOLUME - 303.97 MILLION LITERS

(ALL DEPTHS SHOWN IN METERS)

FIGURE 26 BOTTOM CONTOURS FOR LOG POND 01



AVERAGE DEPTH - 2.03 METERS

VOLUME - 428.12 MILLION LITERS

(ALL DEPTHS SHOWN IN METERS)

FIGURE 27 BOTTOM CONTOURS FOR LOG POND 02

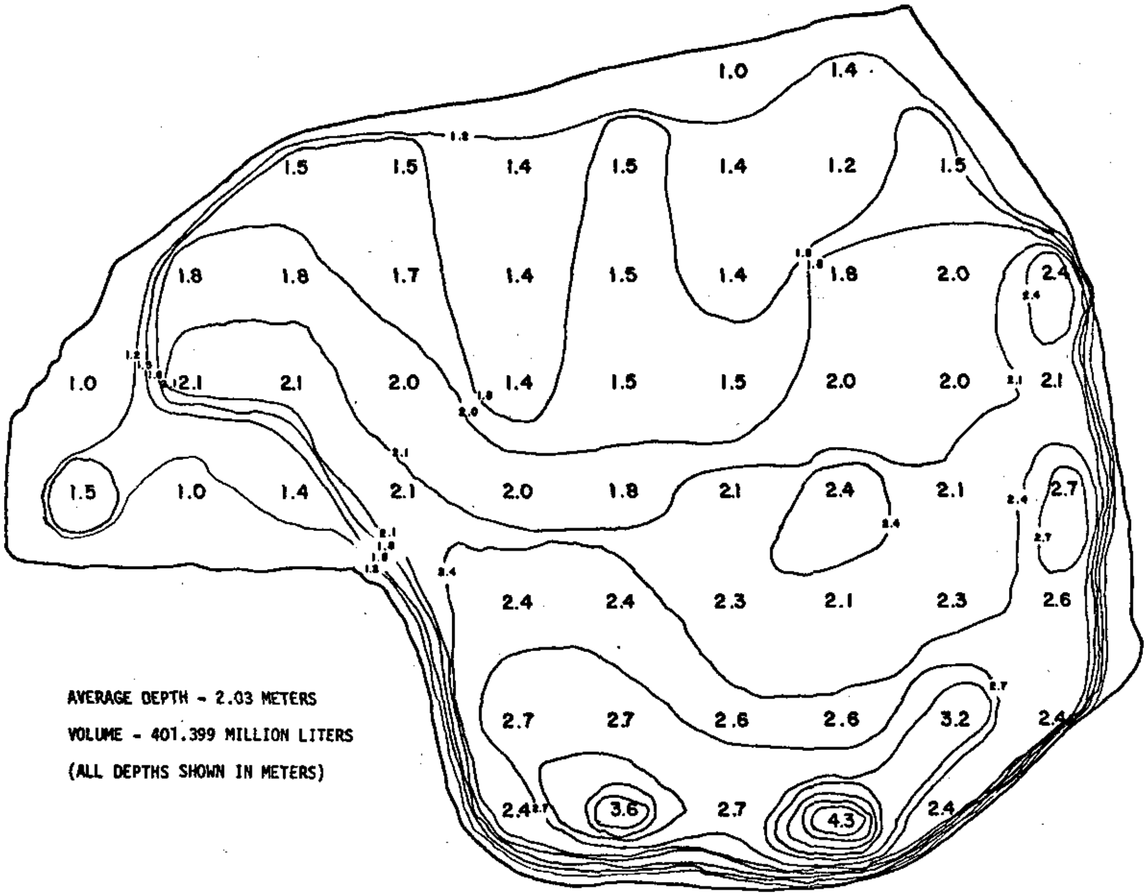


FIGURE 28 BOTTOM CONTOURS FOR LOG POND 03

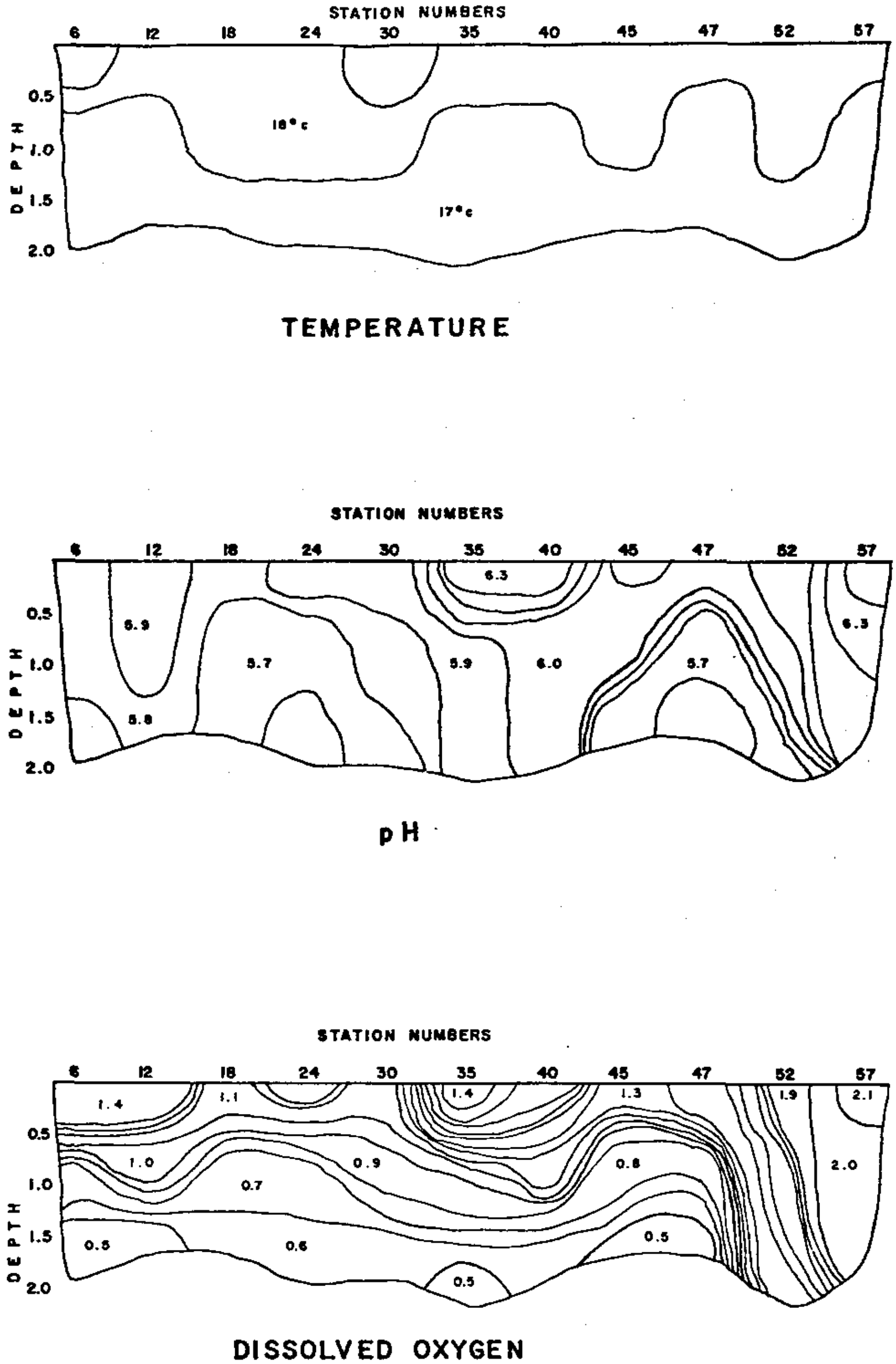


FIGURE 29 TEMPERATURE, pH, AND DISSOLVED OXYGEN PROFILES FOR LOG POND 01

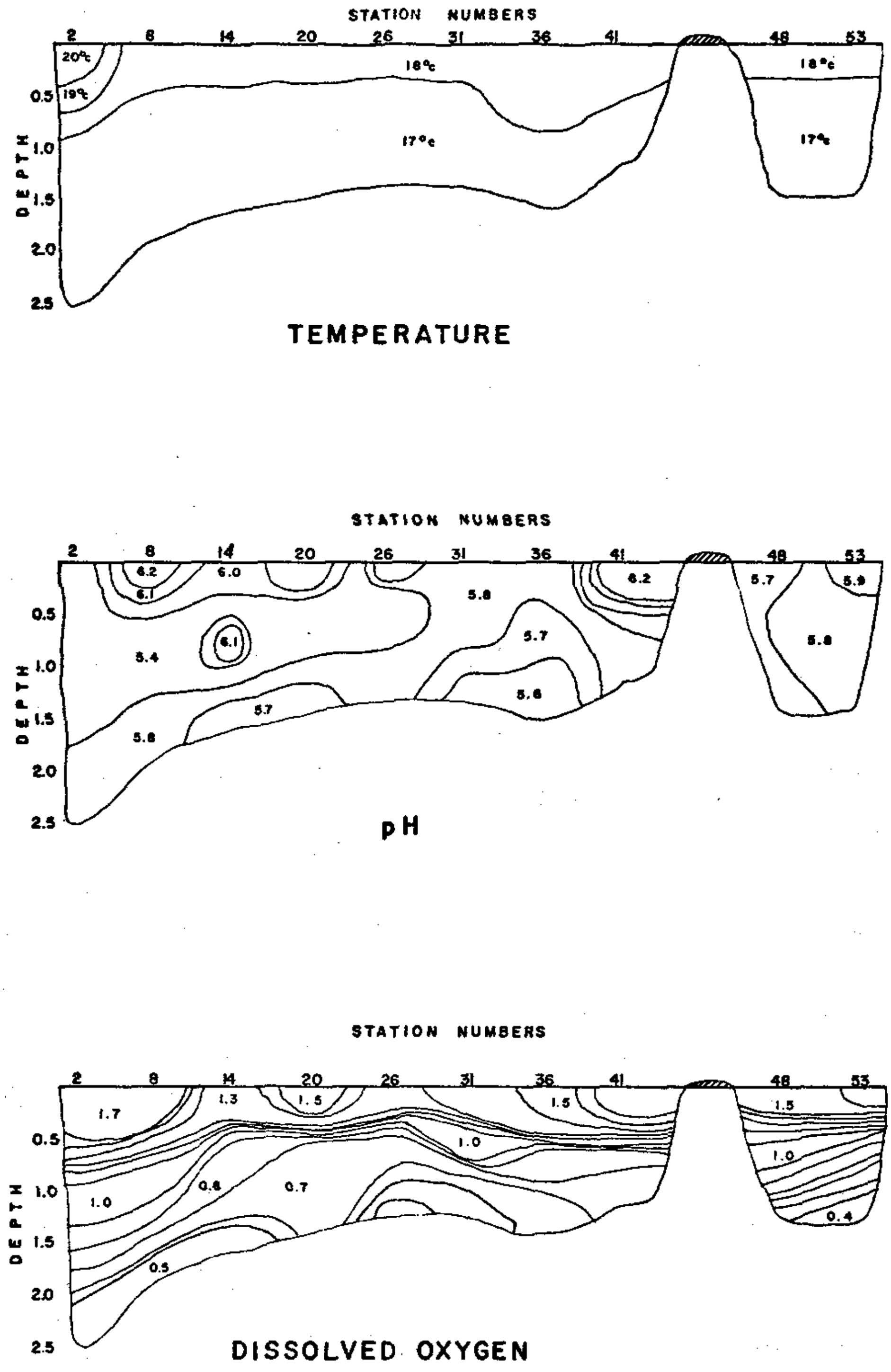


FIGURE 30 TEMPERATURE, pH, AND DISSOLVED OXYGEN PROFILES FOR LOG POND 01

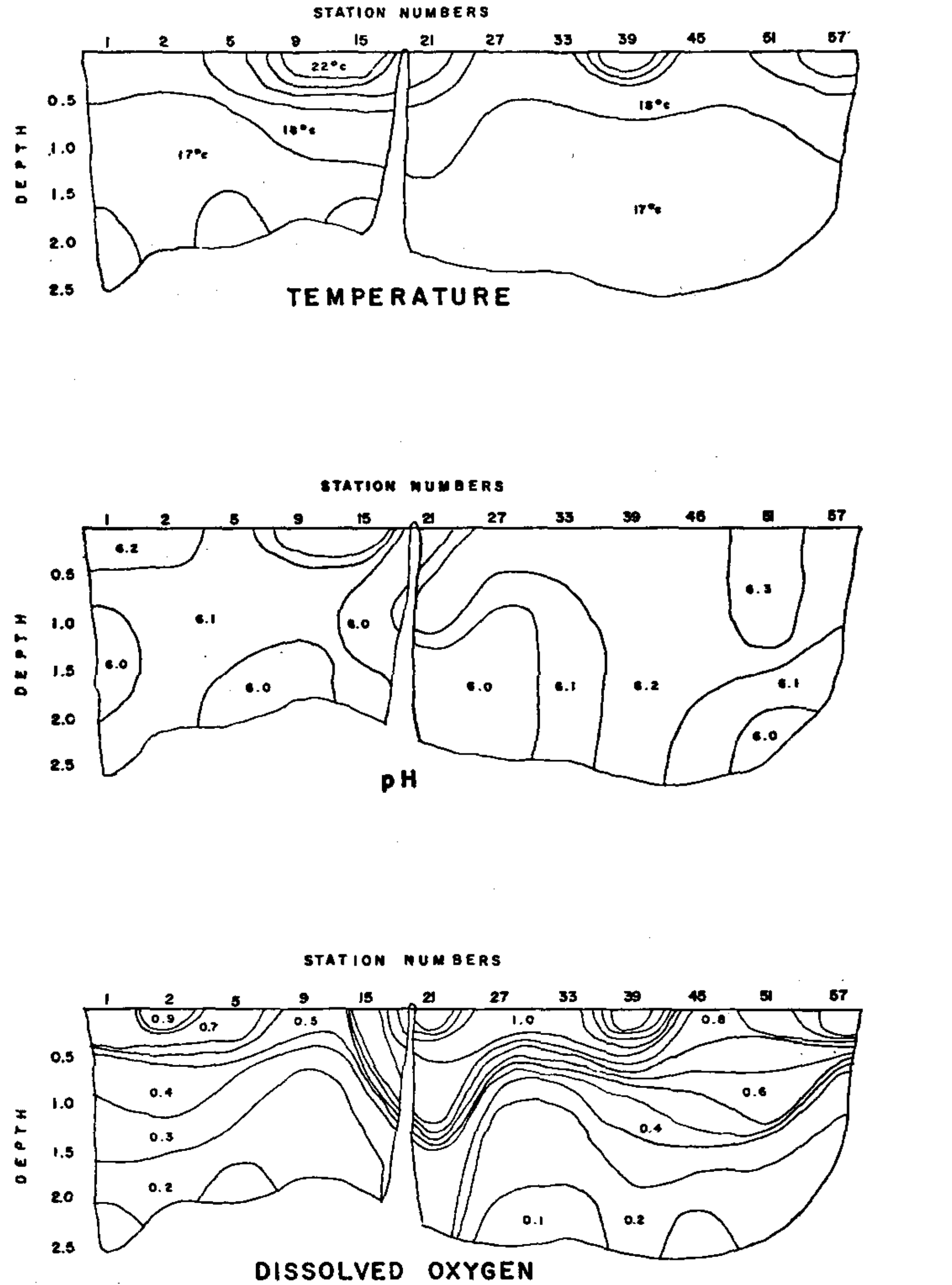


FIGURE 31 TEMPERATURE, pH, AND DISSOLVED OXYGEN PROFILES FOR LOG POND 02

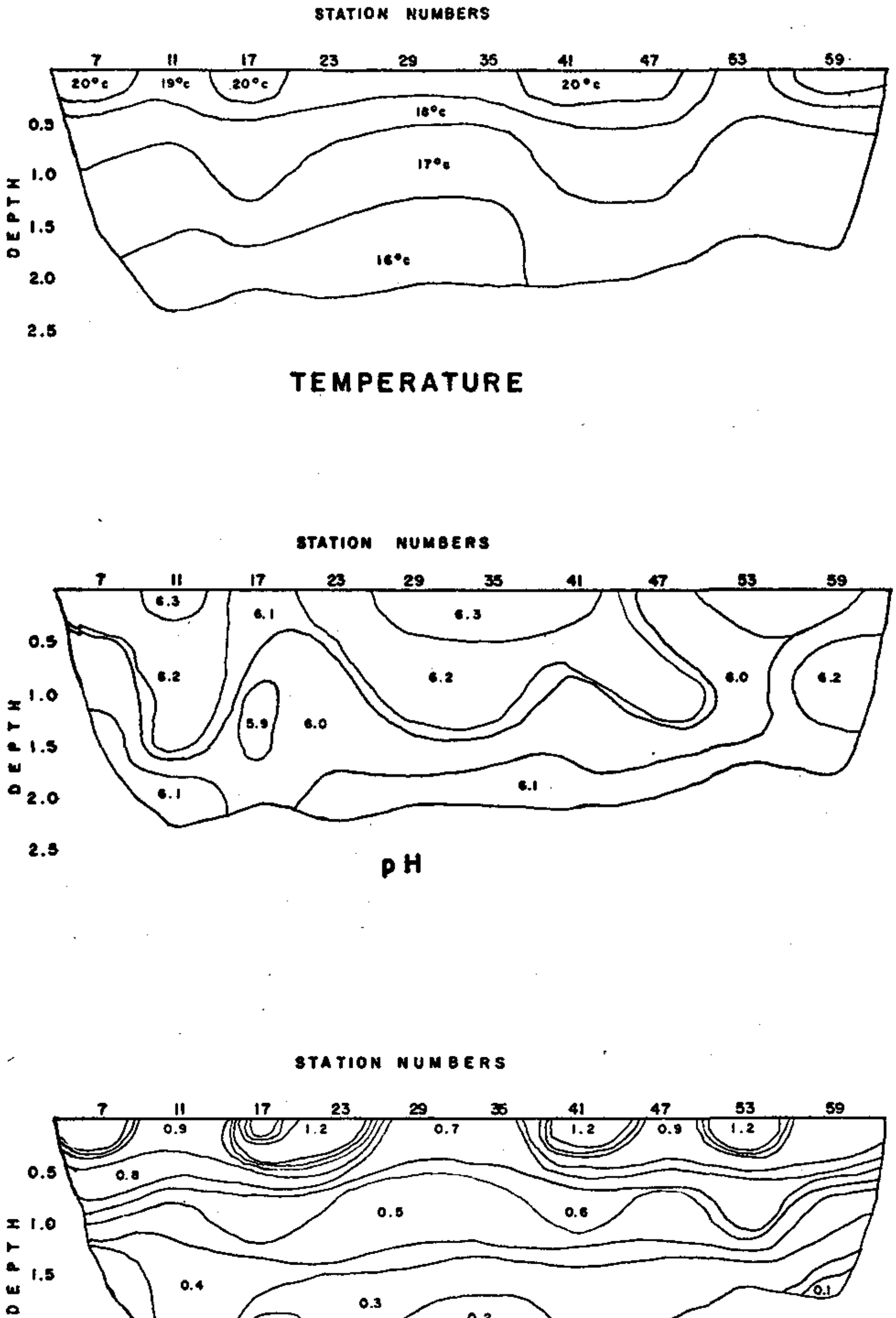


FIGURE 32 TEMPERATURE, pH, AND DISSOLVED OXYGEN PROFILES FOR LOG POND 02

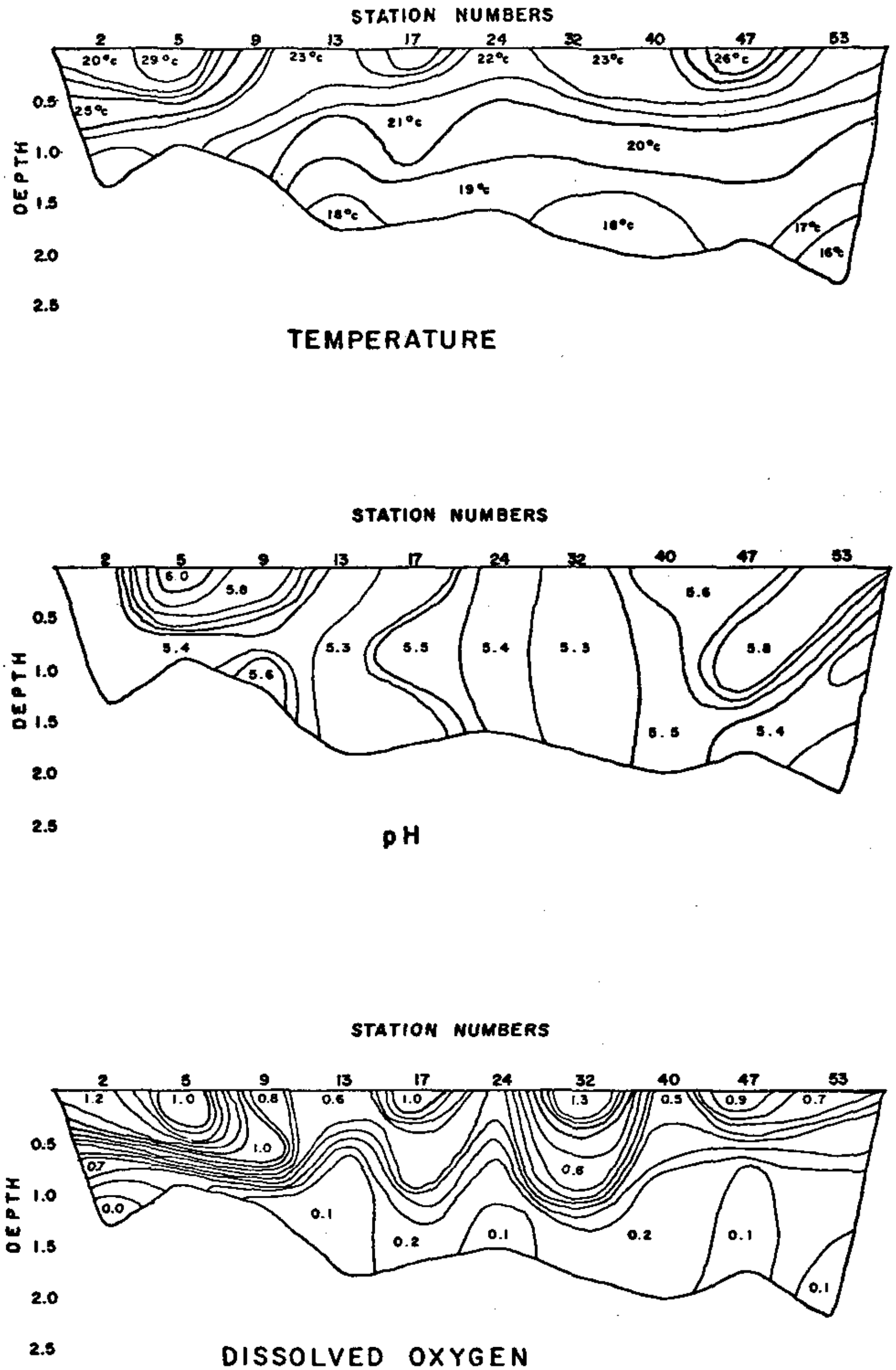
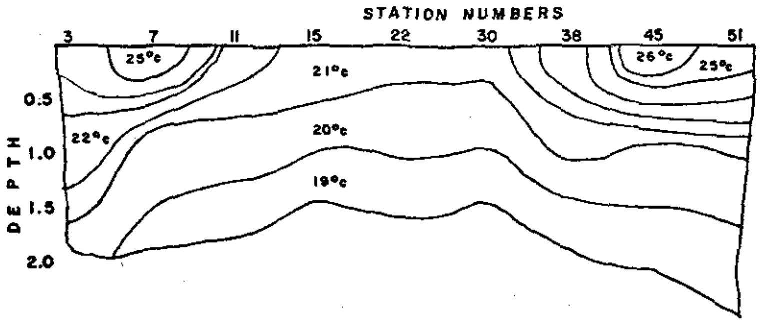
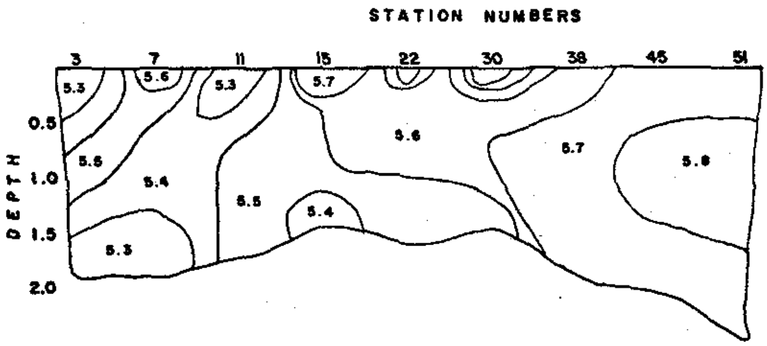


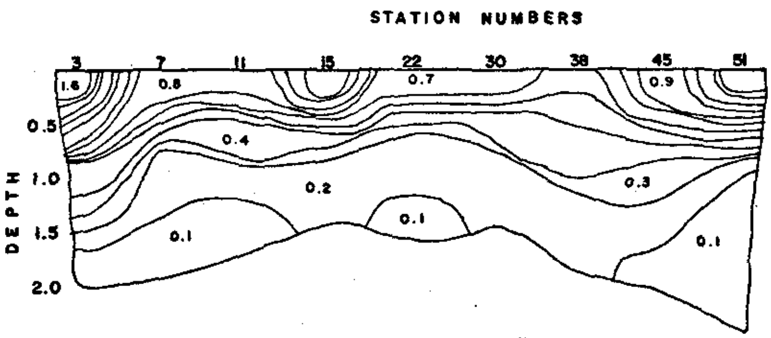
FIGURE 33 TEMPERATURE, pH, AND DISSOLVED OXYGEN PROFILES FOR LOG POND 03



TEMPERATURE



pH



DISSOLVED OXYGEN

FIGURE 34 TEMPERATURE, pH, AND DISSOLVED OXYGEN PROFILES FOR LOG POND 03

(Figure 24) was selected because of the low amount of activity on the pond (even though the log loading on the pond is high) and also because the primary influent to the pond is the effluent from Pond 01 which already contains a moderately high concentration of pollutants. Log Pond 03 (Figure 25) was chosen because there was a high amount of activity on one end of the pond and the pond is a non-overflowing pond during the summer months. In addition to these reasons, the ponds were in adequate geographical proximity that all three could be sampled in the same day and direct comparison of the data was possible.

The three ponds were sampled for three weeks during the summer and for five days at the beginning of winter. Fourteen effluent samples were collected during the first week of sampling from each of the ponds, seven during the second week, and three during the third week. Three to five influent samples were collected during the same period. Four or five surface sample sites over the area of the pond were selected, and one sample from each of these sites was collected each week. These samples were analyzed for 12 selected parameters in addition to the field determinations of pH, Dissolved Oxygen (D.O.) and temperature. The influent and effluent data summary for the ponds is presented in Tables 17 through 19. The average value and the 95 percent confidence range for each of the parameters is presented for the influent and also for the effluent for each week and totally. The number of samples comprising the data involved in that sampling period is also indicated. The surface sample locations are indicated in Figures 23 through 25 and the corresponding data for the locations is shown in Tables 20 through 22. The data from the winter sampling are shown in Table 23.

Sampling sites were established every 200 ft on each of the ponds. At these sites, the depth was recorded, and the pH, temperatures, and D.O. were measured at various depths. Bottom contours for the ponds were established and are shown in Figures 26, 27, and 28. Temperature, pH, and D.O. profiles for the various lines through the pond are presented in Figures 29 through 34. In addition, a diurnal study was conducted on Log Pond 01 and also on Log Pond 02. The data for the diurnal studies are shown in Table 24.

Samples were collected from several other ponds in Oregon, Washington, and Idaho. These samples were analyzed and the data are presented in Table 25.

The three log ponds were studied in the detail described above in order to determine if the concentrations of the various parameters in the effluents were varying with time and also to determine if the concentrations varied spatially in the pond. The data reported in Tables 17 through 19 are the 95 percent confidence range of values for the various parameters for the influent and effluent by week and also the effluents for all three weeks of study. These data indicate that the log ponds studied were at steady state with respect to concentration of pollutants in the effluent stream. The influent data were not

TABLE 26
DATA CORRELATIONS FOR LOG PONDS (01, 02 AND 03)

Independent Variable	Dependent Variable	Correlation Coefficient	Slope	Intercept	$\bar{X}$	$\bar{Y}$	N
01 Pond							
COD	Turbidity	-0.217	-0.0317	5.677	56.892	3.875	24
COD	Color	-0.055	-0.070	124.358	56.892	120.375	24
COD	Nt	-0.088	-0.007	2.408	55.857	2.035	21
COD	BOD5	-0.501	-0.443	45.561	54.854	21.254	24
COD	PO4t	0.424	0.019	-0.099	56.892	0.987	24
COD	TS	-0.409	-3.056	293.928	56.892	120.042	24
BOD5	Nt	-0.304	-0.019	2.407	19.367	2.035	21
PO4t	Nt	0.060	0.094	1.936	1.049	2.035	21
02 Pond							
COD	Turbidity	-0.098	-0.21	10.970	92.521	139.375	24
COD	Color	-0.521	-2.345	356.295	92.521	139.375	24
COD	Nt	-0.340	-0.021	4.433	91.733	2.544	21
COD	BOD5	0.455	0.690	-39.366	92.521	24.474	24
COD	PO4t	0.385	0.023	-0.977	92.521	1.192	24
COD	TS	-0.305	-1.838	404.885	92.104	235.583	24
BOD5	Nt	0.009	0.001	2.531	22.786	2.544	21
PO4t	Nt	-0.037	-0.037	2.541	1.275	2.544	21
03 Pond							
COD	Turbidity	-0.265	-0.019	7.586	131.456	5.043	23
COD	Color	-0.070	-0.252	377.318	131.456	344.174	23
COD	Nt	0.028	0.003	2.907	131.276	3.285	21
COD	BOD5	-0.074	-0.107	46.448	131.450	32.379	24
COD	PO4t	-0.018	-0.001	1.649	131.450	1.552	24
COD	TS	-0.070	-0.168	168.172	131.450	146.083	24
BOD5	Nt	-0.038	-0.003	3.377	33.457	3.285	21
PO4t	Nt	0.160	0.427	2.579	1.653	3.285	21

TABLE 27
RELATIONSHIP OF THE VARIOUS PARAMETERS
TO COD FOR LOG PONDS 01, 02, and 03

Ratio	01	02	03	Average Ratio
Color/COD	2.116	1.509	2.681	2. 02
Turbidity/COD	0.068	0.098	0.038	0.068
BOD/COD	0.338	0.275	0.243	0.285
PO_4/COD	0.017	0.013	0.012	0.014
N_T/COD	0.055	0.041	0.034	0.043
TS/COD	2.110	2.558	1.089	1.919
TSS/COD	0.527	0.421	0.275	0.408

quite as reliably steady as illustrated by the large range of values. The areal data on the ponds indicate that not only were the effluent concentrations steady with time, but also that the effluent concentrations of a parameters represents the concentration of that parameters throughout the pond. The various points in the ponds were chosen for areal sampling because it was anticipated that these would represent sluggish areas in the pond and perhaps contain higher concentrations of pollutants. Because that did not occur, it would appear that the ponds are well mixed with respect to their detention time.

The results of data correlations for the three ponds are shown in Table 26. As indicated by the correlation coefficients in Table 26, poor correlation of the data was observed between all parameters studied, indicating that the data varied in a random fashion. The randomness of the data in this case does not mean that the variations of the parameters are not related, but rather that the parameters are varying insufficiently to cause an observable trend. The ratios between the various parameters for the three ponds are shown in Table 27. It can be seen that the ratios of BOD, PO_4, and N_t to COD seem to be decreasing when progressing from Log Pond 01 to Log Pond 02 to Log Pond 03. This seems reasonable when considering that the age of the pollutants increases in the same order. However, the difference between the ponds is such that the average ratio will be an approximate representation of log ponds for all detention times.

It is recognized that a comprehensive description of the effluent from a log pond must include the following factors:

1. Type of logs in the pond;
2. Number of logs in the pond;
3. Age of the logs;
4. Detention time of the logs;
5. Size of the pond;
6. Hydraulic detention time; and
7. Quality of water entering the pond.

All of the above listed parameters, with the exception of the type of log and the age of the logs were taken into account in an attempt to model the effluent from the log pond. The log pond was considered to be a "continuous feed stirred tank reactor" (CFSTR) with the logs acting as the feed of pollutants and the influent water acting as both the feed of pollutants and the water feed. The use of this model was justified by the uniformity of the log pond effluent with time and also the uniformity of the log pond water from point to point within the pond. The leaching rate of pollutants was assumed to be a first order reaction up to a maximum level that was dependent on the volume of the pond and the number of logs in the pond. The maximum concentration was determined from Log Pond 03 and Log Pond 09 which are no-flow ponds during the summer. The five first order leaching constants for the various ponds calculated from the model varied from 0.00121 to 0.00308 with an average value of 0.00205. The equation for predicting the effluent concentration using the model is:

$$C_{effl.} = \frac{C_o + kKt \quad L}{1 + k \quad \frac{}{t}}$$

Where:

C_{effl} = effluent COD concentration (mg/l)

C_o = influent COD concentration (mg/l)

k = first order rate constant ($days^{-1}$)
t = hydraulic detention time of the pond (days)

L = quantity of logs on the pond (cu m)

V = pond volume (liters)

K = constant to account for maximum COD concentration = C_u V/L

Where:

C_u = ultimate COD concentration in the non-flowing pond (mg/l)

$$K = 2957.3 \times 10^9 \ \frac{mg}{cu\ m}$$

When this equation was used to predict the concentration of the five ponds, and then the predicted value compared with the observed value of the effluent concentrations, the data agreed well as indicated by a correlation coefficient of 0.953.

Using the data collected in this study and the model used for relating that data to the various physical parameters, it was possible to approximate the character of the effluent streams from log ponds for different physical characteristics. These data are listed in Table 28. It can be shown that despite the concentration of the effluent from Pond A being less than that from Pond B, the total amount of materials removed from Pond A per day is significantly higher than that removed from Pond B. In a similar fashion, even though the concentration of pollutants in the water in Pond E is highest of the five ponds, the total pounds per day of pollutants from Pond E is zero because the flow is zero. In addition, the greater depth of Pond D over Pond C, all else being constant, yields lower effluent concentrations and total pounds of pollutants. These observations lead to the conclusion that minimum pollutant release would be obtained by no flow, or if the flow must be allowed, it should be minimized and the pond depth made as great as possible.

TABLE 28
TYPICAL WASTE STREAMS FROM LOG PONDS

Parameter	Log Pond A	Log Pond B	Log Pond C	Log Pond D	Log Pond E
Hydraulic Flow (Cu M/Day)	38,000	3,800	3,800	3,800	0
Log Loading (Thousand Cubic Meters)	19	19	37	37	37
Area (Hectares)	20	20	20	20	20
Depth (Meters)	1.5	1.5	1.5	3.0	3.0
Initial Concentration, C_0	0	0	0	0	0
Calculated Parameters					
Pond Volume (Million Liters)	308.33	308.33	308.33	6 6.73	616.73
Detention Time (Days)	8.146	81.46	81.46	162.94	∞
COD (mg/l)	3.0	26.1	52.3	45.7	179.5
Color (Color Units)	6.3	54.8	109.8	96.0	377.0
N_T (mg/l)	0.13	1.12	2.25	1.97	7.72
PO_{4T} (mg/l)	0.04	0.37	0.73	0.64	2.51
BOD_5 (mg/l)	0.8	7.4	14.9	13.0	51.2
Turbidity (JTU)	0.2	1.7	3.5	3.1	12.2
TS (mg/l)	5.8	50.1	100.4	87.7	344.5
TSS (mg/l)	1.2	10.6	21.3	18.6	73.2

The Model Log Pond

The representative log pond is located in the Northwest. The pond is constructed from a field about 20 ha (50 ac) in size that is fairly flat. Retaining walls for the log pond are formed by dozing the soil from the center of the field to the edge. An effluent structure, usually of concrete, is installed such that a water depth of 1.5 to 3.0 m (5 to 10 ft) is maintained throughout the pond. The pond may receive surface water runoff from an adjacent area, or it may be completely isolated from all precipitation except that falling directly on the pond. In some cases, the pond is fed from springs, irrigation ditches, or rivers. Most log ponds require the addition of water during the dry season.

The logs are dumped from a truck or train into the pond and floated to a temporary storage area. The logs are then sorted with small boats called mules. The logs may be bundled for storage, stored loose, or moved directly to the mill feed area of the pond, if one exists. The logs may be stored in the pond for a year or more, but generally they are stored only long enough to insure an adequate supply for the mill during the season when timber harvesting is difficult.

The model log pond used for consideration in the following sections would have characteristcs similar to those shown for Log Pond C in Table 28. The characteristics of the effluent would also be the same as that for Log Pond C.

STORAGE OF LOGS ON LAND (WET DECKING)

The sprinkling of logs stored on land occurs in all areas of the U.S. The purpose of sprinkling is to prevent deterioration of the wood during the storage period between harvesting and further processing at the facility. Some species of wood are more susceptible to deterioration during this storage period than others. Realistically, it is only necessary to keep the logs wet during dry periods. In general, however, industry practice appears to be that, if the facility practices sprinkling of logs, the system continues to operate during periods of precipitation. The volume of water applied and/or the number of spray nozzles may or may not be adjusted depending on the volume of the logs in storage at any given time.

Most decks are sprinkled with the "rainbird" type of sprinkler which allows about 0.2 lps (3.2 gpm) of water to flow from the nozzle. The number of rainbirds used on a particular land deck does not appear to be related to the size or shape of the deck, but rather to the opinion of the manager of the operation. Flows from as low as 540 l per second per million cu m (20 gpm per mm b.f.) to as high as 6,750 lps per million cu m (250 gpm per million b.f.) have been observed.

In some cases, mist type spray nozzles are used for sprinkling land decks. The flow from these nozzles is considerably less than from rainbird type sprinklers. The water used for sprinkling the deck is usually relatively clean ground or river water. In the arid areas of Oregon and Washington, the water is usually applied in a single use operation, in which the water passes over the deck and then flows off the property to the nearest drainage area. The pollutants present in this runoff are primarily leached materials from the logs.

The recycling of wet deck water is practiced in the South and Southeast and, to a limited extent, in the West. The water lost by evaporation in the recycled wet deck is usually replaced by water from a convenient fresh water source. The runoff from the wet deck during the rainy season is usually allowed to overflow the small recycle pond.

The characterization of the runoff from a wet deck has been attempted and reported in the literature in only one case. Schaumburg reports the measurement of the BOD of the leachate from a large wet deck to be 19 mg/l. It can be estimated that the deck contained about 8.7×10^3 cu m (3.7 million bd ft) of logs and the flow rate of water over these logs was measured as 1,610 cu m per day (0.426 mgd). In addition to this, a laboratory setup was constructed in which the wet deck runoff was recycled. It was found that most of the pollutant parameters increased in concentration up to about 100 hours of operation and then assumed a fairly constant value after that time. It was also found that Douglas fir logs yielded significantly higher pollutant levels than Ponderosa pine logs. This was the opposite of that observed for logs submerged in water.

The data in the literature were found to be inadequate to properly characterize the waste water generated by wet decking. For this reason, eight wet decking operations in the Washington-Oregon area and six in the South and Southeast were studied. The data collected from this sampling program are listed in Table 29. The first eight samples are from the West coast and the last six are from the Southeast and South.

Seven of the eight West coast wet decks sampled did not recycle. Using COD as a measure of the pollution of the water from the wet deck, it was possible to find satisfactory relationships between the COD, the volume of logs in the deck, and the flow rate of the water over the deck. A simple curve fitting technique was used to obtain a relationship of the form:

$$COD = 131.3 \times 10^6 \, (L/Q) + 42.33$$

Where:

L = volume of logs in the deck (cu m)
Q = flow rate of water over the deck (l/sec)

The relationship between the observed COD in the runoff from the seven non recycled wet decks and the calculated L/Q was such that a correlation coefficient between the other parameters measured

TABLE 29A
CHARACTERISTICS OF EFFLUENT FROM WET DECKING OPERATIONS

Plant	PH	Recycle	Color	Turbidity	$B.O.D._5$	C.O.D.	PO_{4_t}	N_t	Total Solids	Total Suspended Solids	Total Dissolved Solids	Total Volatile Solids	Total Volatile Suspended Solids	Total Volatile Dissolved Solids	Phenols (mg/l)	Inventory ([illegible])	Flow (l/sec)	Q/L**	L/Q**	COD
75	-	No	57	6	52.1	67.0	0.73	1.69	105	18	87	77	17	60	44.4	6.9	32.9	174	-	-
75	-	No	29	0.7	11.0	56.6	1.15	0.80	76	4	72	57	7	50	82.6	1.15	7.7	244	-	-
75	-	No	53	6	38.4	45.5	.45	0.59	91	36	55	33	8	25	52.8	1.725	12.6	267	-	-
44	-	No	153	0.9	14.2	133.3	.62	2.24	440	8	432	99	0	99	61.1	3.68	3.7	32	-	-
44	-	No	104	1.9	17.6	107.8	.43	.81	101	28	73	95	1	94	37.1	2.07	4.3	76	-	-
29	-	Yes	99	53	27	98	4.10	1.36	347	50	297	110	91	19	26.7	25.3	20.1	29	-	-
73	-	No	34	10	-	54.9	1.12	1.50	170	85	85	67	44	23	170.8	1.15	7.3	232	-	-
72	-	No	127	5	17.0	78.4	2.89	.76	208	63	145	100	30	70	97.9	46	113.6	90	-	-
76	6.25	Yes	400	10	21.0*	212	0.63	2.63	310	122	188	166	-	-	27	.46	1.8	145	.00700	-
76	6.02	Yes	400	2.5	3.0*	115	0.31	1.90	201	46	155	102	-	-	6	.69	3.2	167	.00600	212
77	6.98	No	100	17.0	- *	16.8	.13	1.23	98	19	79	41	-	-	<5	.23	-	-	-	115
78	7.84	Yes	300	2.5	- *	82.8	0.31	0.88	292	20	272	133	-	-	<5	1.61	11.2	253	.00395	-
79	7.82	No	-	3.2	- *	40.5	.16	.32	232	27	205	98	-	-	0.15	.345	1.2	129	-	82.8
80	7.2	Yes	-	-	191	358	7.0	1.0	826	23	806	246	12	234	20	1.219	.6	18	.05521	358

*Apparent toxicity of samples

**Q/L = flow/inventory

L/Q = inventory/flow

TABLE 29 B

DATA CORRELATION FOR WEST COAST WET DECKING

Independent Variable	Dependent Variable	r*	m	b
COD	NT	0.522	0.010	0.414
COD	Color	0.878	1.317	-22.707
COD	PO4	-0.173	-0.004	1.271
COD	TS	0.741	2.974	-60.774
COD	Turb.	-0.882	-0.085	11.864
PO4	NT	-0.239	-0.215	1.410
BOD	NT	0.230	0.006	1.004
COD	BOD	-0.514	-0.402	63.865

*r = correlation coefficient

and COD could be determined. As can be seen from Table 29A. COD correlated well with color and total solids, but not turbidity. However, the correlation of COD with the nutrients and the nutrients with themselves was very poor. The phosphate concentrations from the wet deck appears to be about 1.0 mg/l or less, whereas the nitrogen concentration appears to be rather erratic. The BOD/COD ratio for the wet decking varied from a low of 0.10 to a high of 0.84. The higher value was higher than observed for any other data in the raw material storage and handling. The high variation in this ratio accounts for the poor correlation between BOD and COD.

The above equation was used to calculate the expected concentration of COD from the log deck reported by Schaumburg and a value of 87 mg/l was obtained. If the BOD/COD ratio were 0.25 (an average value for wet decking), the BOD for this wet deck would be about 22 mg/l. This compares favorably with the reported BOD concentration of 19 mg/l.

The southern wet decks with recycle fit the form of the equation, but the constants are different. The equation for characterizing southern wet decks with recycle is:

$$COD = 168.9 \times 10^{6} \ (L/Q) + 109.8$$

The fit between the observed COD and the calculated parameters L/Q was such that a correlation coefficient of 0.915 was obtained.

The one observation of southern wet decking without recycle did not fit either equation. In addition, the western wet deck with recycle did not fit either equation.

The concentration of pollutants in a wet decking water system is a function of the number of logs in the deck, the species of logs, the flow rate of water being sprayed over the deck, and whether or not the wet deck water is recycled. If the runoff from the wet deck is recycled, the concentration of pollutants is generally higher, but these pollutants are not discharged from the system unless rain water causes overflow from the recycle pond.

The Model Plant

Using the equation derived in this study and "typical" wet deck characteristics, it is possible to generate the effluent quality for a wet deck with recycle and one without recycle. These "typical" effluents are shown in Table 30.

The hydraulic flow and the number of logs in the deck are considered to be typical values based on field operations. The concentrations of pollutants in Table 30 are not inclusive of all the concentrations to be expected, but may be considered to be representative of a typical wet decking operation.

TABLE 30
TYPICAL WASTE STREAM FROM WET DECKING OPERATIONS

Parameter	Western Wet Deck, No Recycle	Southern Wet Deck, With Recycle
Hydraulic flow, l/sec.	9.5	9.5
Logs in deck, cu.m.	3500	3500
Type of Discharge	Continuous	Intermittent* or None
Area required, hectares	1.52	1.52**
Calculated or Estimated Parameters		
COD, mg/l	77.7	155
BOD, mg/l	20	38
Color (color units)	80	50
Nt, mg/l	1.2	1.3
PPO4, mg/l	0.7	0.5
Total Solids, mg/l	Variable	Buildup
Total Suspended Solids, mg/l	50	00

*Intermittent flow occurs whenever rain is enough to exceed the unused volume of the sedimentation basin

**Will require additional area for recycle pond

STORAGE OF LOGS ON LAND (DRY DECKING)

Since no water is used in the dry storage of logs, no studies in regard to the generation of pollutants have been conducted. Realistically, however, it must be considered that a significant polluted stream might be produced by storm runoff from dry decks.

Some differences between wet decks and dry decks during precipitation periods can be expected. One primary difference is that the runoff from an established wet deck tends to be channelized, i.e., has eroded definite patterns of flow, and to be essentially free of soil particles. The storm runoff from a dry deck, on the other hand, tends not to be channelized and usually contains considerable concentrations of suspended solids contributed by the soil. In this respect, a new wet deck can be more comparable to a dry deck. This effect was observed in the effluent from one wet decking operation which even after 24 hours from spray initiation still contained significant soil contamination.

It was felt early in the study that despite the lack of information concerning dry decking, it might be possible to establish a definitive relationship between the effluents of wet decking and dry decking and thereby characterize the dry decking effluent. In an attempt to accomplish this, a field experiment was conducted.

Fifty-three slash pine logs were placed on supports such that the logs were maintained at a distance of 46 cm (18 in) above the ground. The 5 meter (16 foot) wide, one and a half meter (five foot) high deck contained logs with an average length of 12.3 m (40.4 ft), an average butt diameter of 31.55 cm (12.42 in), and an average top diameter of 18.44 cm (7.26 in). The butt ends were all placed at one end of the deck. Three plastic lined basins were constructed under the log pile in such a manner as to collect all water percolating through the decks at each end and in the middle.

The first period of precipitation amounted to a total of 1.47 cm (0.58 in) of rain fall and samples were collected from the basins after the first 1.22 cm (0.48 in) and at the termination of precipitation. The results of analyses showed little difference in the two samples, and the values shown in Table 31 are averages for the two samples.

Twenty days later a second rainfall deposited 1.24 cm (0.49 in) of rain and ten days after that a third storm produced 0.89 cm (0.35 in). The results of sample analyses are shown in Table 31.

A comparison of the results in Table 31 with those in Table 29 shows that the concentrations of pollutants leaching from the dry deck are markedly higher than any from the wet deck samples.

For example, the COD concentrations for wet deck runoff ranged from 15 to 150 mg/l with one sample concentration of 212 mg/l

TABLE 31
LEACHATES FROM DRY DECK EXPERIMENTS

Date	Rainfall (Inches)	Total Leachate Collected (liters)	pH	Color	Turb.	BOD_5	COD	TOC	PO_4	N_T	TS	TSS	TDS	TVS	Phenols
10/31/73	0.42	594	4.9	362	24	265	1097	200	1.67	0.83	868	162	706	782	206
11/1/73	0.16	155	4.5	357	29	299	1037	214	1.74	1.61	974	164	810	875	211
11/19/73	0.49	534	6.0	455	36	211	773	141	1.49	2.05	-	-	482	398	223
11/28/73	0.35	299	5.7	409	-	112	594	173	0.59	0.81	509	132	377	77	83

whereas the COD concentrations observed from the dry deck leachate were generally in the range of 600 to 1200 mg/l. The COD load contributed by the dry deck for the three rainfalls amounted to about 1265 grams (2.75 lb). In this particular case the load was contributed in about one day of rainfall spread over about 45 days. The equivalent load from a wet deck with no recycle would be contributed in about two days. This tends to indicate that even though the concentrations of the pollutants in the leachate coming off the dry deck are high, the total load contributed by the deck during the actual rain periods is about the same as a wet deck.

This data is only for one log pile of one particular species of wood under fairly similar precipitation and climatic conditions. The difference in concentrations of the pollutants in this leachate and the wet deck leachate is so great, even though the total load may be similar, that a correlation between wet decking and dry decking is not felt to be possible at this time.

STORAGE PILES OF FRACTIONALIZED WOOD

Fractionalized wood and wood products consisting of chips, sawdust, planer shavings, bark, etc., are commonly stored in piles in the timber products industry. These piles and the associated water pollution are similar in some respects and dissimilar in others. In terms of waste water streams, a prime consideration must be given to the quantities of materials that can be expected to be leached from the piles. There are several factors which affect leaching rates. These include: 1) type or species of wood in the pile, 2) sizes of particles in the pile, 3) amount of water generated by the pile, and 4) age of particles in the pile. The effects of species on leaching rates can be illustrated by Table 32 which presents the results of analyses of cold water solubles from the bark and wood of several species. A considerable variation of concentrations can be observed.

Particle size has an effect on leaching rate in that larger particles generally tend to have slower leaching rates than smaller particles because of the smaller areas of surface exposure. The relative size of particles in piles is illustrated graphically in Figure 35 since they are usually greater than 10 mm in size.

Perhaps the most important parameter in the determinations of the amount of pollutants generated by a pile of fractionalized wood is the amount of water that passes from the pile. The water may originate from one or more of several sources. When the particles are blown on to the pile, water may be added to control dust. Water may be generated by ground water seeping into the pile or it may originate from storm runoff flowing through the pile. The water may be released from particles because of microbial decomposition. Most of the water from particle piles, however, originates from rain falling directly on the pile and passing through it.

TABLE 32
ANALYSIS OF COLD WATER SOLUBLES IN
BARK, WOOD, AND MOSS PEAT

Species	pH		Water soluble[1]		Kjeldahl nitrogen		C/N ratio	
	Bark	Wood	Bark	Wood	Bark	Wood	Bark	Wood
			%					
Western redcedar:								
Untreated	3.2	3.5	2.95	6.99	0.14	0.06	378:1	810
Extracted	4.5	4.6	-	-	.13	.06	392:1	835
Redwood:								
Untreated	3.2	4.4	2.35	1.67	.11	.07	473:1	753
Extracted	4.8	5.6	-	-	.11	.06	457:1	876
Red alder:								
Untreated	4.6	5.8	11.64	1.43	.72	.13	71:1	377
Extracted	5.0	6.0	-	-	.81	.15	62:1	320
Western Hemlock:								
Untreated	4.1	6.0	3.95	3.47	.27	.04	212:1	1,234
Extracted	4.4	4.4	-	-	.24	.03	223:1	1,618
Ponderosa pine:								
Untreated	3.8	4.4	4.35	2.68	.12	.04	422:1	1,297
Extracted	3.9	4.2	-	-	.13	.06	429:1	895
Sitka spruce:								
Untreated	4.9	4.1	10.89	1.27	.41	.04	130:1	1,214
Extracted	6.4	6.4	--	-	.40	.04	127:1	1,194
Douglas fir:								
Untreated	3.6	3.4	5.49	4.65	.12	.04	471:1	1,268
Extracted	3.8	3.3	-	-	.11	.04	513:1	1,242
Sour sawdust	-	2.0	-	12.81	-	.06	-	893
Moss peat:								
Untreated	3.8		1.04		.83		58	
Extracted	4.4		--		--		--	

[1] Total solids in 12 successive 1:10 water extractions, 24 hours each

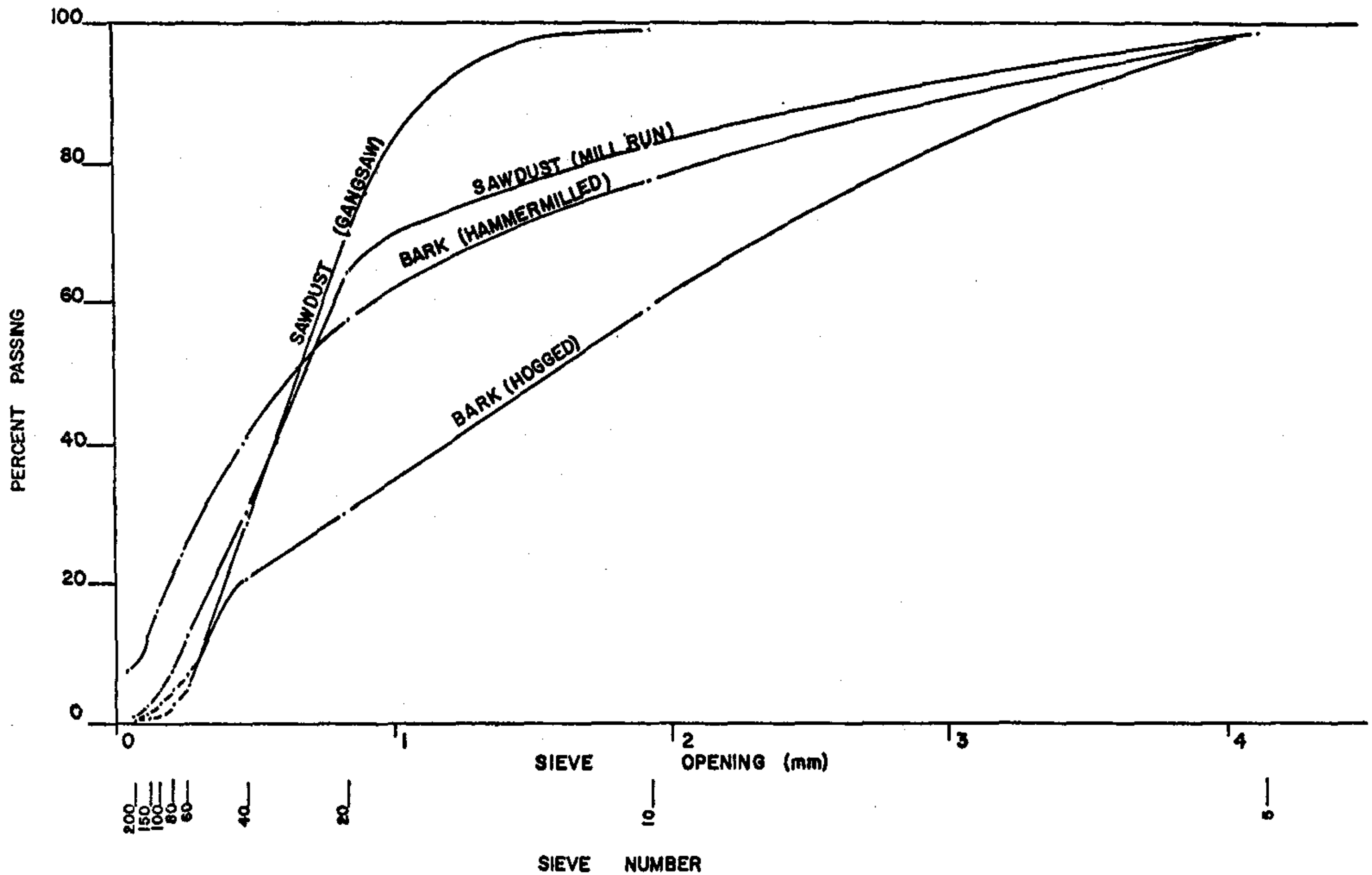


FIGURE 35 PARTICLE SIZE ANALYSIS FOR DOUGLAS FIR BARK AND SAWDUST

The age of a fractionalized wood pile is an important criterion in determining the quantity and quality of leachates from the pile in that older piles may be saturated and yield their water more readily. The older pile may also be undergoing microbial decomposition which can increase the concentration of leachates or, conversely,the microbial decay may have progressed to the point that further leaching produces relatively low concentrations.

The factors discussed above and others affect the character of the waste stream from a fractionalized wood pile to varying degrees. In many cases, the problem is compounded by the pile being located on bare earth which may allow the waste stream to percolate into the ground. Partly for these reasons few studies have been conducted on leachates from fractionalized wood piles and, in fact, few cases of visible leachates have been observed. Virtually no characterization of the waste waters originating from piles of fractionalized wood had been established prior to the current study.

While there are no data in the literature concerning the character of leachate from fractionalized wood piles in the field, there have been three laboratory studies performed on leachates from piles, and numerous works on the alteration of chip quality in chip piles experiencing biological decomposition. An annotated bibliography prepared by Hajny covers comprehensively the effects of chip quality in outside storage.

The laboratory study by Asano and Towlerton illustrates the pollutant levels that may be expected in leachates from chip piles. The study reported COD concentrations of greater than 500 mg/l and color values of about 3,000 units. About 10 hours of agitation were required to produce these concentrations. Using submerged agitated bark, Benedict observed COD concentrations of about 4,000 mg/l, BOD concentrations of greater than 2,000 mg/l, and color values of about 7,000 units for a mixture of fresh softwood and hardwood bark. The Benedict study is probably more representative of the leachates to be expected from a bark pile than the laboratory study by Asano and Towlerton is of the leachate to be expected from a chip pile. The ratio of bark to water in the Benedict study is closer to that expected in a bark pile than the ratio of chips to water in the Asano and Towlerton study. Another bark study by Sproul and Sharpe shows COD concentrations of about 500 mg/l and color units of about 2,000. These concentrations remained relatively constant over the duration of the 90 day test.

During the course of the current study, leachates from several bark, chip, and sawdust piles were collected and analyzed. As indicated in Table 33 the data seem to be highly variable. In addition, it can be observed from Table 33 that bark piles, chip piles, and sawdust piles all produce leachates that can be high in concentration. It was possible to investigate the effect of rainfall intensity on the quantity and quality of leachate from chip and sawdust piles by critically examining the data shown in

TABLE 33

CHIP PILE RUNOFF RESULTS

Source	Date 1973	Flow (1/sec)	Color	pH	NT	COD*	PO_4	BOD*	TS*	TVS*	TSS*	TVSS*	TDS*	Phenols mg/1
Chip Pile+ Runoff Plant 80	8/2	--	1560	5.1	--	489	--	117	3927	2544	164	126	3763	--
Chip Pile+ Runoff Plant 80	8/3	--	2250	5.6	--	4368	--	630	4119	2652	854	560	3265	--
Chip Pile+ Runoff Plant 80	10/16	0.1	--	6.2	9.18	1190	2.00	222**	1050	731	67	--	--	239
Bark Pile Runoff Plant 82	1/3	0.6	1600	--	--	8700	--	--	4800	--	--	--	--	--
Sawdust Pile# Runoff Plant 82	1/3	0.9	250	--	--	1530	--	--	1850	--	--	--	--	--
Sawdust Pile Runoff Plant 81	1/3	0.1	--	--	--	4358	1.8	--	5404	2964	--	--	--	--
Chip Pile Runoff Plant 81	10/17	0.2	550	6.95	--	237	0.30	3.8	543	309	91	--	--	19

*Expressed as mg/1

**Possible toxicity

+Collected and analyzed by Temple Industries, Dibold, Texas

#Collected and analyzed by CH_2M-Hill, Corvallis, Oregon

TABLE 34
CHIP PILE RUNOFF SUMMARY

Date	Point of Runoff Sample	Flow 1/Sec.	BOD (mg/1)	COD (mg/1)	Rainfall cm/day
1/8/73	Redwood	1		460	
9:00 a.m.	Whitewood	2		478	
	Sawdust	1			2.44
	Total	4			
1/9/73	Redwood	10	840	2370	
9:00 a.m.	Whitewood	16	180	750	
	Sawdust	6	210	553	4.14
	Total	32			
1/12/73	Redwood	6		2500	
1:00 p.m.	Whitewood	10		943	
	Sawdust	6		1220	3.35
	Total	22			
1/13/73	Redwood			2460	
	Whitewood			278	
	Sawdust			238	010
	Total				
1/18/73	Redwood	4		1820	
9:00 a.m.	Whitewood	6		797	
	Sawdust	0.5		672	3.07
	Total	10.5			
3/19/73	Redwood	3	294	1186	
4:00 p.m.	Whitewood	4	210	711	
	Sawdust	4	320	948	1.42
	Total	1			

*Data from industrial contact 623

Table 34. A plot of the flow from the various piles and the total flow versus the rainfall intensity (Figure 36) shows that the flow from each of the piles does not begin until the rainfall intensity exceeds a certain value. The data for the month of March has been omitted from the plot in Figure 36. The rationale for this omission was that during the month of January the chip and sawdust piles were saturated to a certain low level. Therefore, when it rained with an intensity greater than a certain level (in this case 2.21 cm (0.87 in) per day), the chip or sawdust piles could not absorb the rainfall at that rate, and a portion of the rainfall came off the pile as though the pile was acting as a roof. In March, after two additional months of rainfall, the piles were saturated to a greater degree and, therefore, the intensity of rainfall required to produce runoff from the piles was significantly less. This is evidenced by the fact that a rainfall intensity of 1.42 cm (0.56 in) per day in March produced a runoff rate that would have required a rainfall intensity of about 2.92 cm (1.15 in) per day in January. Looking at the total yield that could be expected from the two chip piles with areas of 2.35 and 3.12 ha (5.83 and 7.70 ac) and the sawdust piles with an area of 0.39 ha (0.97 ac), the average flow if the rain fell at a uniform rate for 24 hours would be about 10 lps (153 gpm). These figures, 10 lps (153 gpm) versus 11 lps (173 gpm), agree quite well considering the inexact nature of most of the measurements involved in the data. The agreement of the two figures signifies that the chip and sawdust piles were absorbing relatively little precipitation.

The COD data in Table 34 shows that the COD is relatively constant for each of the effluents no matter what the flow. This indicates that the quantity of pollutants leached from the pile is directly proportional to the flow from the piles. A washout phenomenon is expected, but it may occur at greater flow-offs from the piles. No explanation can be given for the much higher concentration of COD in the leachate from the redwood chip pile than from the whitewood chip pile. No information about the species of chips contained in each pile was supplied with the data. Typically chip piles for the particleboard or insulation board processes experience rapid turnover and saturation of the piles may never be obtained.

The data represented by entry number 4 in Table 33 were not the only data received on that bark pile. BOD and COD concentrations for three flows were received and BOD and COD loads coming off the pile were calculated therefrom. This data appears in Table 35. It can be seen that the amount of COD and BOD leached from the pile increases about 60 percent when the flow increases from 0.8 to 3.4 lps (12 to 54 gal per minute). The flow increase from 3.4 to 4.7 lps (54 to 75 gpm) did not increase the COD and BOD load. Apparently the bark pile reached the washout point at about 3.4 lps (54 gpm) whereas the chip and sawdust piles had not reached the washout point at 32 lps (500 gpm).

The seepage of the absorbed water from the particle pile is an expected phenomenon, but was observed only for sample locations

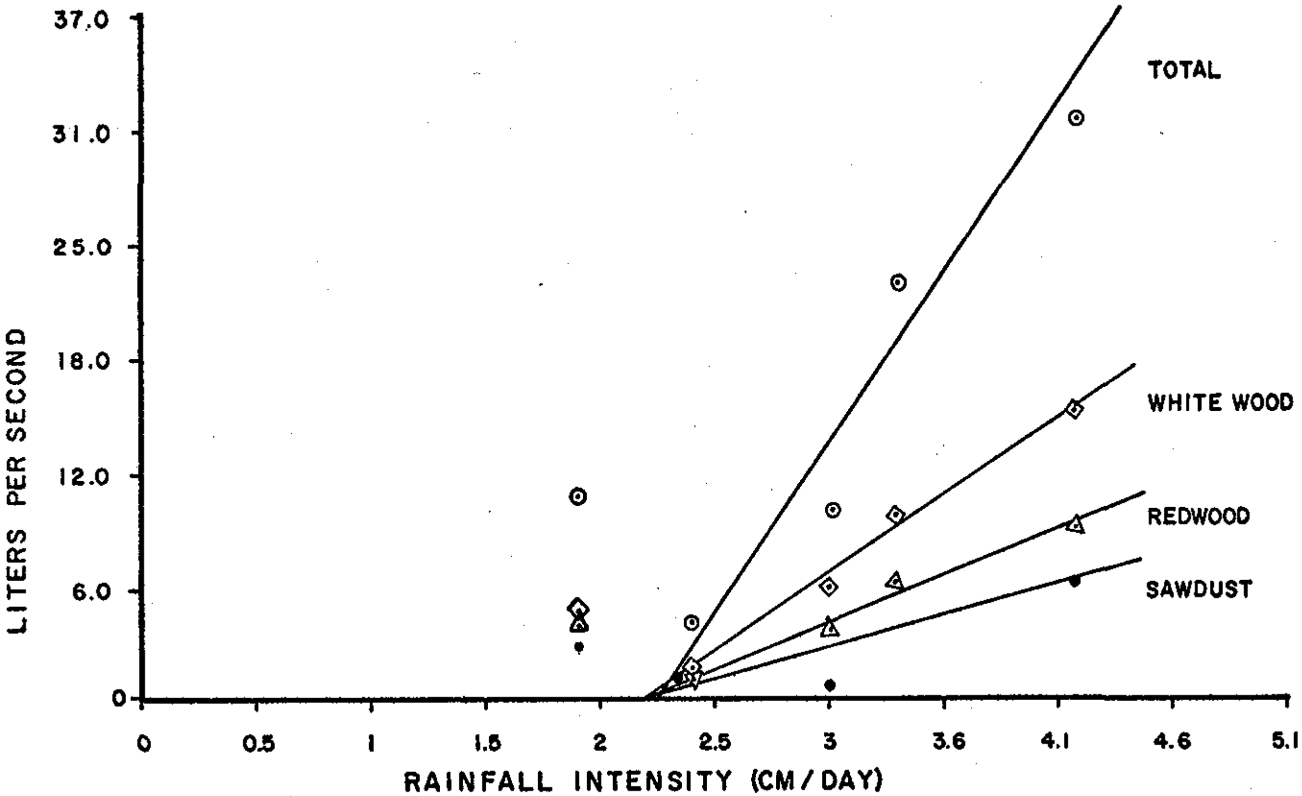


FIGURE 36 RUNOFF FLOW RATE VS RAINFALL INTENSITY FOR WHITEWOOD AND REDWOOD CHIP PILES AND A SAWDUST PILE

TABLE 35
BARK PILE EFFLUENT CHARACTER

Discharge (l/Sec.)	COD (mg/l)	COD (Kg/Day)	BOD5 (mg/l)	BOD5 (Kg/Day)
1	6,930	453	3,800	248
3	2,530	745	1,300	382
5	1,850	755	870	355

TABLE 36
"TYPICAL" EFFLUENT STREAM FROM A PARTICLE PILE

Parameter	Approximate Value
Flow	3 liters/second during heavy precipitation
COD	3,000 mg/l
BOD	700 mg/l
Color	1,000 color units
PO4	1.5 mg/l
Nt	7 mg/l
TS	2,000 mg/l
SS	500 mg/l

numbers 6 and 7 in Table 33. For both of these two samples, rain had occurred for one or two days previous to sample collection and the rate of leachate production on the sample day was low. However, the strength of the effluent was relatively high.

Typical Effluent from Fractionalized Wood Piles

Fractionalized wood piles, like most other aspects of timber products raw material storage, emit highly variable effluent waste streams both with respect to flow and concentrations. The leachate stream can emanate from the pile because of the water held within the pile, because of water flowing on the ground through the pile, or because of water running off the pile during rainfall periods. Regardless of the origin, the concentrations of pollutants in the effluent stream are high. No modeling of the piles was attempted, but the typical effluent stream is considered to have the characterization listed in Table 36.

LOG WASHING

As previously mentioned, the practice of log washing is not common in the industry. Furthermore, the method of washing, the amount of water used, and the resulting waste water characteristics will vary from mill to mill. The waste water characteristics can be expected to vary somewhat depending on the season of the year and the conditions under which the log was harvested. Thus, during rainy, seasons of the year, the characteristics of the solids removed from the logs will differ from those removed under dry conditions. However, these solids are generally settleable and because the log wash water can be recycled, these variations are not of significance.

Typically, log wash water will be low in COD and solids as illustrated in Table 37 (from information collected during this study). The data shown illustrate waste water characteristics for recycled wash water as well as non-recycled wash water. It should be noted that the COD values for the recycle systems are approximately twice the concentration found in the non-recycled system. This indicates the possibility of a concentration gradient which inhibits to a great extent further leaching from the logs. It should also be noted that the reported values for solids do not include settleable solids since settleable solids concentrations vary considerably with log harvesting conditions. Their removal is the primary reason for log washing.

The representative log washing operation is located at a sawmill producing 59,000 cu m (25 million bd ft) of lumber per year. The log wash operates for 16 hours per day, five days per week, and requires 25 l/sec (400 gpm) of water at a pressure of 8 atmospheres (117 psi). This is a non-recycle system and, therefore, the waste water characteristics are similar to those of Mill A, Table 37.

TABLE 37

RAW WASTEWATER CHARACTERIZATION LOG WASH WATER

Mill	COD mg/l	Total Solids mg/l	Suspended Solids mg/l	Dissolved Solids mg/l	Total Volatile Suspended mg/l	Volatile Suspended mg/l	NT mg/l	PO4T mg/l	Turb. JTU	Color Units	Phenol mg/l
A	97	134	73	61	62	-	5.6	.10	-	70	-
B*	240	442	218	214	214	98	3.68	3.0	530	274	79
C*	258	354	204	150	170	-	1.04	.58	13.0	-	-

*Recycle systems

SAWMILLS

Water usage at sawmill operations varies significantly. A majority of small sawmills do not produce their own power and use no water at all except for sanitary purposes. On the other hand, a sawmill producing power, washing logs, and wet decking logs may use over 38,000,000 l of water per day (10 mgd).

This disparity in volume illustrates the difficulty in attempting to discuss a typical sawmill. However, a discussion of various possible sources and volumes of water use follows.

Table 38 provides a list of sources of water usages in an actual sawmill and approximate maximum water requirements. The volume of water used is 737 l/sec (11,682 gpm) or 63,600 cu m/day (16.8 mgd). Of this volume, approximately 93 percent is related to the production of power rather than to the operation of the sawmill itself. Actually, only 0.4 l/sec (six gpm) of the total is directly related to the mill operation and this is absorbed by the sawdust. However, the fact that a large volume of water is used in the vicinity of the sawmill is important in that in many cases this water becomes contaminated prior to leaving the mill yard. This is the case, for instance, when the point of discharge of uncontaminated cooling water is a log pond.

In many cases the range of water use prohibits the development of waste water characteristics; however, such information as available is presented. It should be noted that the information presented represents the best available information on present status of water use in the industry. Future technological and economic developments may result in increased or decreased water usage. It should also be noted that the following discussion is directed toward the sawmill processes and does not include a discussion of log storage waste waters or those resulting from the presence of glue using operations such as end-jointing which *might be present at a sawmill. These are discussed elsewhere in* this report.

One possible water usage in a sawmill is saw cooling water. The practice of spraying a fine mist on saws, especially band saws, is common. Where water is employed for cooling the volume is small, generally less than 0.06 to 0.12 l/sec (1 to 2 gpm) and no waste stream is created as all moisture is absorbed in the sawdust. This practice is sometimes employed in cooling other types of saws, especially gang saws where the volume of water used may be on the order of 0.18 to 0.25 l/sec (3 to 5 gpm). As the volume of water used increases, so does the probability of creating a discharge. For most saws, however, the volume of water used can be restricted such that no discharge is necessary. In fact, only one saw cooling system was observed to produce a waste water stream.

A notable trend in the industry, is toward the use of thin or narrow-kerf saws. The narrow-kerf saws are somewhat more susceptible to dynamic instability than most present day saws.

TABLE 38
WATER USAGE FOR AN ACTUAL SAWMILL WITH
POWER PLANT AND LOG STORAGE

Source of Use	Water Pumped 1/Sec	Volume Lost 1/Sec	Volume Discharge 1/Sec
Condenser No. 1	316	--	316
Condenser No. 2	316	--	316
Grate Cooling	3	--	3
Boiler Scaling	3	--	3
Saw Cooling	0.4	0.4	--
Compressor Cooling	8	--	8
Boiler Makeup	28	28	--
Bark Wash	19	--	19
Miscellaneous	6	6	--
Fire Protection (normal)	2	2 2	--
Log Deck (summer)	38	38	--
Totals	739.4	74.4	665

*Sanitary use not included. Also, maximum fire protection use is 388 liters per second.

Saw guides, employed to compensate for this instability, use water, oil and sometimes air mixtures to reduce friction and pitch buildup on the saws. Such a system designed for an edger, for instance, would utilize 0.06 to 0.6 lps (1 to 10 gpm) of water and up to 2.6 l/hr (0.7 gal/hr.) of water soluble oil. Thus, oil content of the cooling water may be on the order of 1000 mg/l. As saws become thinner, larger volumes of water may be required; however, at this time characterization of any waste water that might result is not possible. Also, the current state of development of thin-blade saws is such that the sawguide water required is of a volume that all water is absorbed by the sawdust.

Many sawmills, especially older ones, utilize steam for various purposes. In general, where steam is utilized for power such as in steam driven log carriages, a condensate can be expected to occur. Generally, the steam powers the carriage and then the steam is blown-off or wasted to the atmosphere. It is also common practice to inject an oil mist into the steam to insure proper lubrication of the equipment. In some cases, the oil contaminated condensate may be of sufficient volume to form a waste water stream; however, the volume and oil content of such streams is highly variable and is usually intermittent.

Cooling water is generally non-contact water such as that used for cooling compressors and condensers. Turbine pumps and various other types of hydraulic equipment may require bearing cooling water. The volume of such cooling water varies considerably but is generally contaminated by only a slight amount of oil, if any.

A common practice at sawmills is the dipping of lumber, both green and dressed, in a preservative solution of, most commonly, pentachlorophenol. There should be no discharge of this material. However, often times the dip vats are not covered and, therefore, receive precipitation and may overflow. Also, as the lumber is removed from the dip tank, drippage on the ground may occur. It is also probable that the dip tank eventually becomes heavily silted with debris and may require blowdown.

Another source of water usage is in lubrication of chain belts and other conveyor systems. The water is sprayed on the chains in small volumes. No waste water should result, however, as the water is absorbed by bark or sawdust.

There is no necessity for waste water generation from most cleanup operations in sawmills or planing mills. A small volume of water, generally less than 35-75 l/day (10-20 gpd) will be required for cleaning various types of applicators which may be employed. Small spray compartments are utilized to apply stains and moisture resisting compounds to lumber. The waste water generated in cleaning the compartments and nozzles should be recycled and used in makeup for the next batch of material.

While no necessity exists for waste water generation from cleanup operations, it is commonly occurs, especially in cleanup of areas underneath the mill. The volume used for this purpose has been reported by industry to be as high as 23,000 lpd (6,000 gpd). This stream contains a considerable amount of floating wood particles and also contains soluble wood and bark constituents, dust, oils, and greases. COD and total solids concentrations of 100 and 400 mg/l, respectively, have been observed.

Consultation with industry representatives as to the necessity for this practice resulted in the conclusion that the cleanup of mill floors can be accomplished by dry cleaning (sweeping) rather than by the use of water.

The utilization of bark and other wood residues for fuel may result in a number of waste water sources including leachates from hogged fuel piles and the presence of bark washing or bark pressing operations. Possible leachates from bark piles were discussed previously in this section and that information can be consulted to obtain an indication of their characteristics. Bark washing or pressing operations have not been observed in sawmills and no further information is presently available.

The presence of boilers may result in boiler blowdown and demineralized backwash. Similarly, furnace grates may require some water for cleanup. Non-contact grate cooling water may also be required. Air pollution devices required to reduce emissions may be wet-scrubbers which require bleed-off of a small percentage of the recycled flow. Typically, the volume of such bleed-off is about 0.6 l/sec (10 gpm) with a solids content of 0.5 to 1.0 percent.

Figure 37 is a water balance for a sawmill producing 230 cu m (100,000 bd ft) per day of dried lumber. It is assumed for this model mill that the moisture content of the incoming logs is 50 percent and that the dried lumber moisture content is 12 percent by weight. It is further assumed that the lumber overrun equals the kerf loss, where overrun is defined as the difference between the measured volume of a log and the actual volume of lumber produced, and kerf loss is the volume of wood lost to sawdust in sawing.

The volume of water used for log washing is equivalent to 25 l/sec (400 gpm), 24 hours per day, and is considered to be discharged without recycle. The headrig water usage is typical of a steam driven log carriage. The effluent is considered to be lost to the atmosphere, the ground or absorbed in the sawdust. The saw cooling water shown is equivalent to 0.6 l/sec (10 gpm), 24 hours per day, and represents the total saw cooling water usage for the mill. No discharge results from this usage because of adsorption in the sawdust. The volume of boiler makeup and blowdown and compressor cooling water is based on actual mill usage and it is assumed that these discharges are not further contaminated by contact with wood or wood residues. The water used in the dip vat is for dilution of concentrated preservative

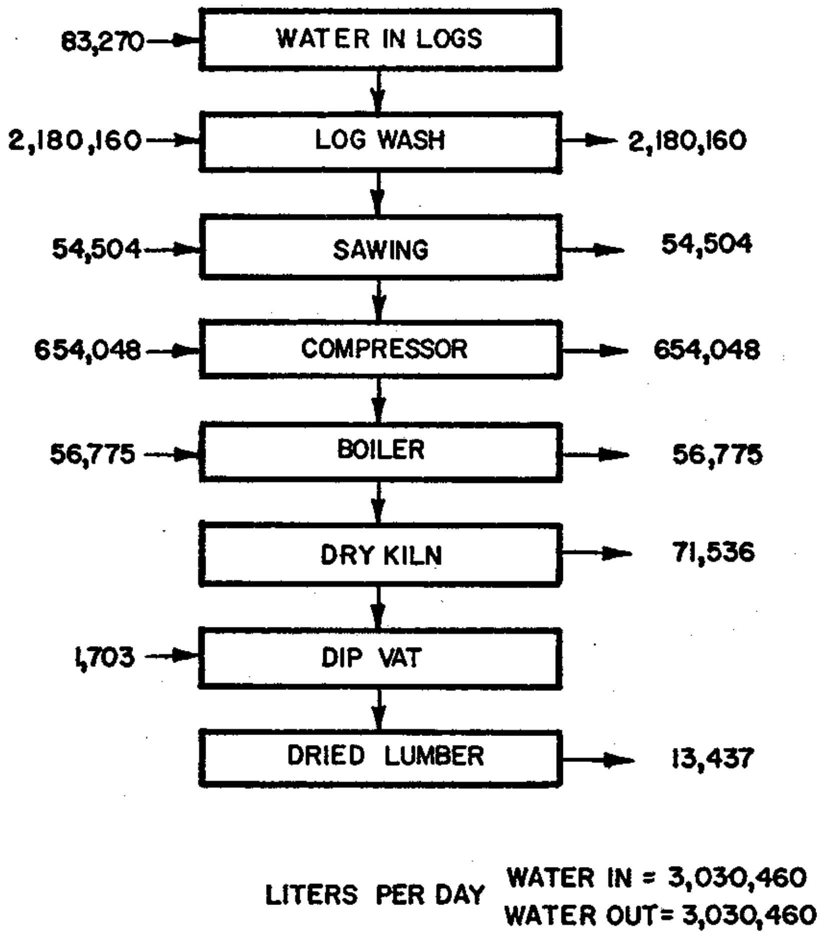


FIGURE 37 WATER BALANCE FOR A SAWMILL PRODUCING 60,000 CUBIC METERS PER YEAR

compounds. The model system assumes a covered dip vat which does not receive rainwater. The dry kiln is assumed to result in no discharge as 100 percent of the steam condensate is returned to the boiler. The discharge of 71,500 lpd (18,900 gal/day) shown from the kiln consists of water vapor driven from the green lumber.

Thus, the model sawmill is managed in such a manner as to produce discharges only from log washing, compressor cooling, and boiler blowdown, and the various potential discharge points such as mill cleanup and other sources previously discussed are not present because of proper water management.

FABRICATION

The discussion of water use and waste water characteristics for the unit process of fabrication contained herein does not include the subcategory of fabrication which employs mechanical fasteners and non-water soluble adhesives since it requires no water and generates no waste water. Therefore, this discussion is concerned only with the use of water soluble adhesives in fabricating operations and the resulting waste water.

Water usage involved with the use of adhesives varies considerably depending mainly on the form in which the resin is delivered, i.e., whether the resin is in a dry, powdered form or a liquid or emulsified form. Table 39 is a list of the most commonly used resins with the percentage by weight of resin, catalysts, and additives, and potential makeup water.

Melamine, urea, and urea formaldehyde may be purchased in either dry or liquid forms. Those resins delivered in liquid form require no water for makeup but may require dilution to the proper concentration (Table 39) to obtain a desired viscosity. Dry resin forms require a substantial percentage of makeup water as shown. Phenolic, urea formaldehyde, and protein are used much more extensively in the manufacture of plywood than elsewhere. Table 40 illustrates the amount of glue used at several mills for specified products and the potential makeup water requirements. It should be noted that makeup water is actually required only for the melamine urea mix while the other resins may require some water for viscosity control.

Other than the small volume of water used for mixing certain resins, the only water use in fabricating operations is in cleanup of glue spreaders and mixing tanks. In a typical operation, the equipment requiring cleanup may consist of some or all of the following:

- Glue Applicator (double roller, extruder, end or edge jointer)
- Resin Mixing Tank
- Resin Storage Tank
- Catalyst Mixing Tank
- Catalyst Storage Tank

TABLE 39
MAKEUP REQUIREMENTS FOR VARIOUS MIXES

Resin Type	Resin, Percent by Weight of Glue Mix	Catalyst, Additives Percent by Weight of Glue Mix	Makeup, Water Percent by Weight
*Melamine Urea (Borden MU-607-F)	80	16	4
Melamine Urea (Melural)	65	-	35
*Urea Formaldehyde (Borden 5H-FM-GA)	80	15	5
Urea Formaldehyde (Borden 5H)	75	-	25
Casein Blend (Borden S-97)	28	-	72
*Vinyl Acetate (Borden WB-905)	90	5	5
Phenolic (Borden Cascophen 31)	75	-	25
*Phenol Resorcinol (Cascophen LT-75-FM-282)	83	13	4
Protein (Borden Casco S-230)	75	-	25

*Liquid Resins

Figure 38 illustrates a typical liquid resin glue line, including catalyst mixture, and a typical dry resin glue line requiring only water for mixing. The volume of water used in cleanup varies from operation to operation depending on the number of applicators and mixing tanks, the frequency of cleanup, and cleanup techniques. The number of applicators is related to the production capacity of the operation and is also a function of the efficiency of the whole operation. Thus, efficient lay up operations in a laminating plant can increase production without increasing the number of applicators required.

The number of storage and mixing tanks present is determined by the production of the plant, the amount of glue required per day, the type of glue used, and the type of applicator used. Generally, liquid resins such as phenol resorcinol require controlled temperature storage in tanks. This type of glue also requires the addition of a catalyst which is generally a powdered substance requiring makeup water and mixing prior to its being added to the resin. Mixing of the resin and catalysts, generally, occurs in a separate mixing vessel. The exception to this is observed where extruder applicators are used. In this case, mixing may occur during transfer of the resin and catalyst from their respective storage tanks by passing them through a helical mixing chamber. Powdered resins usually require only dry storage and one mixing tank.

The frequency of cleanup of mixing vessels is usually daily. According to industry representatives, resin storage tanks do not require cleaning. Glue applicators have been observed to be cleaned daily, once per shift, and even twice per shift. Cleanup is required whenever use is suspended on any applicator. Various cleanup techniques which can be utilized to reduce the volume of water required will be discussed in detail in Section VII, Control and Treatment Technology. These techniques include the use of steam, high pressure nozzles, dry scraping, and the application of grease where possible to applicator surfaces. Table 41 indicates waste water volumes observed at various mills and operations during these studies.

Waste Water Characteristics

Characteristics will vary considerably from mill to mill depending on the type of resin used and the volume of water used during cleanup. This degree of variability complicates any attempt to develop waste water characteristics. However, such data as are available on characteristics of various glue wastes are presented in Table 42. These data are the product of analyses of actual waste water streams during this study.

In order to more thoroughly characterize the various glue wastes found in fabrication, samples of undiluted resins were analyzed. This is considered adequate characterization in that, as demonstrated in Section VII, no discharge of the wastes should occur and adequate control is obtainable without further characterization of the wastes. In order to relate these

TABLE 41
VOLUME OF WASTE WATER REPORTED BY VARIOUS MILLS

Mill	Type of Product	Type of Glue	Volume of Lumber (cu m/day)	Number of Applicators/Mixing Tanks	Frequency of clean-up (times per day	Volume of Wastewater (liters/day)
A	Garage Door	Polyvinyl	2	1/0	1	380
	Beams	Phenol Resorcinol	30	1/1	1	190
	Finger Jointed Lumber	Polyvinyl	-	1/0	1	190
B	Beams	Phenol Resorcinol	190	2/1	1	380
C	Beams, Decking	Phenol Resorcinol	470	5/2	1	4,500
	Finger Jointer	Resorcinol	-	2/0	6	2,300
D	Decking	Melamine Urea	20	1/1	1	3,800
	Beams	Phenol Resorcinol	10	1/1		

TABLE 42

CHARACTERISTICS OF GLUE WASWATER (mg/l)

Mill	BOD	COD	TS	DS	SS	TVS	VDS	VSS	Phenols	Nt	PO4	PH
1	15,900	16,700	7,910	6,850	-	-	-	-	4.16	21.8	2.46	9.77
2	-	-	8,880	6,310	-	-	-	-	0.14	1,640	20.2	5.25
3	710	5,670	5,890	3,360	2,530	-	-	-	-	-	-	10.8
4 a	4,880	3,841	1,284	545	739	886	235	651	127	3.28	1.19	-
4 b	-	-	5,917	687	5,231	5,116	403	4,713	327	952	4.95	-

NOTE: Mills 1 and 2 use phenolic glue
Mill 3 uses urea glue
Mill 4a uses phenol resorcinol
Mill 4b uses resorcinol

analyses to expected waste water characteristics, a dilution of 40 to 1 of water to glue is assumed to occur. The results of these analyses are presented in Table 43. The data demonstrate the variability in concentrations one would anticipate because of the different glues. The analyses presented for the phenolic, protein, and urea glues were taken from a publication by Bodien. The remaining analyses were performed during this study.

Model Operation

For the purpose of developing control technology and associated costs for fabrication operations, a model fabrication operation has been developed. The model fabrication operation may be producing any of a variety of products such as doors, decking, end-jointed lumber, or laminated beams. Thus, production rates are not as meaningful as an indicator of expected volume of waste water as is the number of pieces of equipment requiring cleanup. On this basis, two model fabricating operations are assumed:

Model I consists of one double roller spreader, a finger jointer, and a small mixing tank. The type of glue used may be any of those previously discussed. Observation of various cleanup operations indicate that approximately 750 lpd (200 gpd) of waste water results from cleaning the above equipment as follows:

Double roller spreader	- 370 lpd
Finger jointer	- 190 lpd
Mixing tank	- 190 lpd
Total	750 lpd

Model II is applicable to large industrial glue users other than plywood and is most applicable to the laminated structural products industry. A large laminated beam plant, for instance, may use five face glue spreaders, extruder or roller type; three finger jointers; a catalyst mixing tank; and either a catalyst storage vessel or a resin-catalyst mixing tank. The spreaders will require cleanup on a daily basis while the finger jointers are cleaned once per shift, i.e., three times per day. Other possible water usages that can be expected are glue mixing room floor cleanup and delivery truck washdown. Occasionally imperfect batches of glue may require dumping and subsequent equipment cleanup. The expected volumes of waste water for such an operation are as follows:

Spreaders (5)	- 1890 lpd
Finger jointers (3)	- 1700 lpd
Catalyst Mixer	- 380 lpd
Glue mixing tank (2)	- 760 lpd
Miscellaneous cleanup	- 950 lpd
Total	5680 lpd

TABLE 43

AVERAGE CHEMICAL ANALYSIS OF GLUE
WASTE WATER (ASSUMING A 40; 1 DILUTION WITH WATER)

Analysis (mg/kg)	Phenolic Glue	Protein Glue	Urea Glue	Casein Glue	Melamine Urea	Phenol Resorcinol	Polyvinyl Acetate
COD	16,325	4,425	10,525	5,500	11,600	26,000	15,000
BOD	12,500	220	4,875	-	-	-	-
TOC	4,400	1,300	2,250	-	-	-	5,000
PO_4T	3	7	18.9	-	-	-	-
TKN	30	300	533	-	-	-	-
Phenols*	12,850	45.3	-	3,600	1,200	102,500	-
S.S.	2,300	1,475	86,500	-	-	-	1,000
D.S.	7,625	2,950	5,150	-	-	-	1,000
T.S.	9,925	4,425	13,750	23,000	6,000	1,400	12,000
TVSS	42,000	850	8,650	-	-	-	5,600
TVS	86,000	3,425	13,750	6,600	-	-	12,000

*Phenols = Kg/Kg

INSULATION BOARD

Specific Water Uses

An insulation board plant producing 270 metric tons/day discharges 3,400 cu m per day (0.9 mgd) of waste water and evaporates an additional 380 cu m per day (0.1 mgd) of water. While the major waste water stream results from excess process white water, quantities may also be discharged from such operations as chip washing, dryer washing, and finishing, and from air pollution contol devices. The waste waters resulting from the handling and storage of raw materials have been previously discussed.

Chip Washing - After the appropriate raw material handling operations previously discussed, the first step considered to be part of the subcategory of insulation board production is chip washing. Chips may be washed in order to remove grit, dirt, sand, metal, and other trash which may cause excessive wear and possible destruction of the refining equipment. In additon to removing undesirable matter, chip washing may result in chips with a more uniform moisture content and, in northern climates, assists the thawing of frozen chips. Chip washing is practiced by virtually all plants utilizing chips as a raw material and plants utilizing chips as a major portion of their furnish comprise approximately 70 percent of the insulation board industry. In the future, with the projected increase in the use of forest residues and whole tree utilization, essentially all mills are expected to be using chip washers.

Water used for chip washing is usually recycled to a large extent. A minimum makeup of approximately 400 l per metric ton (95 gal per ton) is required in a closed system because of water leaving with the chips and with sludge removed from settling tanks. However, up to 4,200 l per metric ton (1,000 gal per ton) water usage has been reported from mills that discharge quantities of chip wash water to waste. Water used for makeup in the chip washer may be fresh water, cooling water, vacuum seal water, or recycled process water.

Process White Water - Water used to process and transport the wood from the fiber preparation stage through mat formation is referred to as process white water. The water use in this area is represented in Figure 39. The process white water, accounting for over 95 percent of a plant's total waste water discharge (excluding cooling water), will be discussed in terms of two streams: 1) fiber preparation white water system and 2) the machine white water system.

The fiber preparation white water system is considered to be the water used in the refining of stock up to and including the dewatering of stock by a decker or washer. As previously discussed, there are three major types of fiber preparation utilized in the insulation board industry: 1) stone groundwood, 2) mechanical disc refining (refiner groundwood), and 3) thermo-

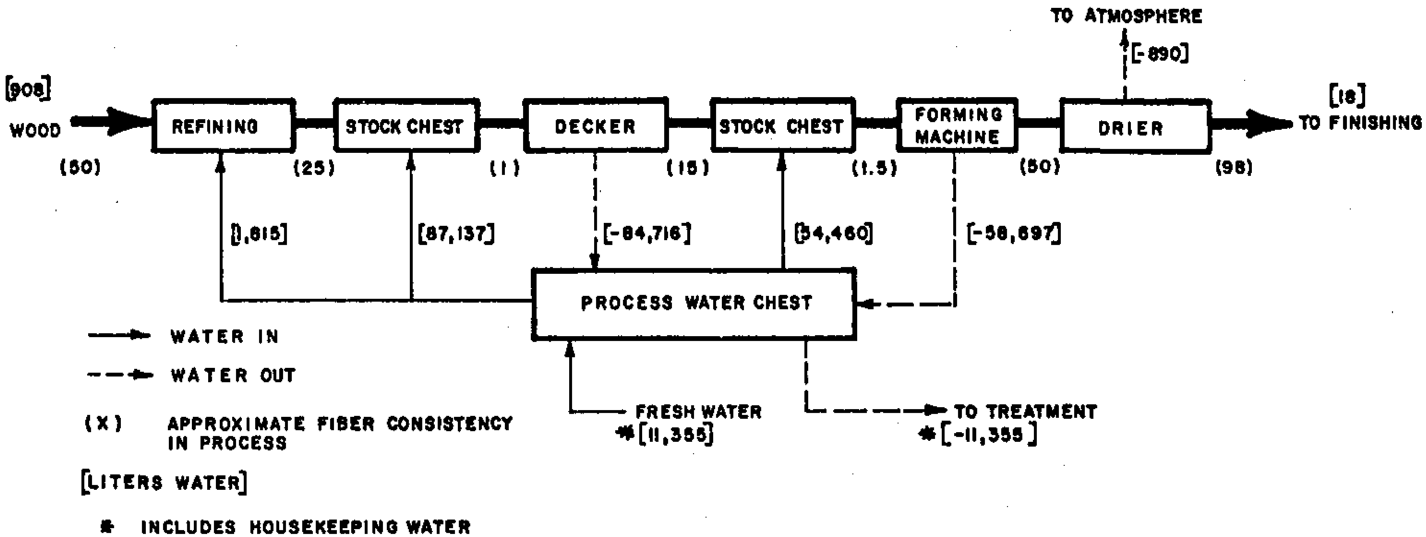


FIGURE 39 WATER BALANCE FOR A TYPICAL INSULATION BOARD PROCESS

mechanical disc refining. The water volume utilized by each of the three methods is essentially the same. In the general case, as shown in Figure 39, the wood enters the refining machine at approximately 50 percent consistency (50 percent solids by weight), and is fiberized and diluted to a consistency suitable for screening (approximately one percent). The stock is then dewatered at the decker to a consistency of approximately 15 percent before being repulped. This is a water deficient section of the process in that more makeup water is necessary than water is discharged because of the quantity of water leaving with the stock. The variations of water use by the refining process are determined by the point where the water is added. In all cases water is added to dilute the stock as it leaves the fiber preparation section. However, in the case of stone groundwood, the stock is flushed from the refining machine by a shower of water that is sprayed onto the revolving stone. There is some water used for consistency control in the mechanical and thermo-mechanical disc refiners. Also, water is added in the thermo-mechanical pulping in the form of steam prior to the chips entering the refiner.

In the machine white water system, after the dewatered stock leaves the decker at approximately 15 percent consistency, it must again be diluted to a consistency of approximately 1.5 percent to be suitable for mat formation. This requires a relatively large quantity of water of approximately 60,000 l per metric ton (14,400 gal per ton). The amount of dilution required can be calculated from the relationship:

$$M(y) = M(x)/C - M(x)$$

where:

M(y) = mass of dilution water required M(x) = mass of wood being diluted, and C = consistency.

The redilution of the stock is usually accomplished in a series of steps. The stock usually receives an initial dilution down to approximately 5 percent consistency, then to 3 percent, and finally, just prior to mat formation, to approximately 1.5 percent. This sequence is done primarily for two reasons: 1) to allow accurate consistency controls and more efficient dispersion of additives, and 2) to reduce the required stock pump and storage capacities.

During the mat formation stage of the insulation board process, the stock is dewatered to a consistency of approximately 40 to 50 percent. Subsequently, in the dryer, the mat is dried to less than 5 percent moisture.

The water produced by the dewatering of stock at any stage of the process is usually recycled to be used as stock dilution water at another stage of the process. However, for reasons discussed in Section VII, <u>Control and Treatment Technology</u>, there is a need to bleed-off a considerable quantity of excess process water. In most cases the bulk of the total waste water produced by an insulation board plant will consist of this water.

<u>Drying</u> - The boards leaving the forming machine with a consistency of approximately 40 percent are dried to a level greater than 97 percent in the dryers. This water is evaporated to the atmosphere and there is no water discharge from the operation. It is, however, necessary to occasionally clean the driers to reduce fire danger and maintain proper heat transfer. This produces a minor waste water stream of about 11,000 l (3,000 gal) per week in most operations.

<u>Finishing</u> - After the board leaves the dryer, it is usually sanded and trimmed to size. The dust from the sanding and trim saws is often controlled by dust collectors of a wet scrubber type and the recovered dust is recirculated back into the process for use in making board. The water that is fed into the scrubbers is sometimes excess process water; however, fresh water is occasionally used. This water usually returns to the process with the dust.

Plants that produce coated products such as ceiling tile usually paint the board after it is sanded and trimmed. Paint composition will vary with both plant and product; however, all plants utilize a water based paint. The resulting washup of this paint produces approximately 400 l (100 gal) of water per ton of product which is contributed to the waste water stream or is metered to the process white water system. In addition, there are sometimes imperfect batches of paint mixed. These batches are occasionally discharged to the waste water stream or metered to the process white water system.

<u>Broke System</u> - Reject boards and trim are reclaimed as fiber by recycling. This is done by placing the waste board and trim into a hydrapulper and producing a fiber slurry that is reused in the process. While there is need for a large quantity of water in the hydrapulping operation, the water is normally recycled process water. There is normally no water discharged from this operation.

<u>Miscellaneous Water Usage</u> - Other water usage in insulation board plants include water used for cooling, for seal water in the vacuum pumps, for screen washing, for fire control, and for general housekeeping. It is common practice to use cooling water and seal water as makeup water in the process water system. The water used for washing screens in the forming and decker areas usually enters the process water system. Housekeeping water can vary widely from plant to plant depending on plant operation and many other factors. A reasonable estimate for housekeeping water usage is 400 l per metric ton (100 gal per ton) of machine production.

Waste Water Characterization

Characteristics of insulation board plant waste waters are essentially the same as those of the water discharged from the process white water system. This is because the major portion of the waste water pollutants results from leachable materials from the wood and additives added during the formation process. The materials leached from the wood will normally dissolve into solution in the process white water system. However, if a chip washer is utilized, a portion of the solubles are dissolved in this process. A small fraction of the waste water load results from cleanup operations in the finishing process; however, these have little influence on any characteristics except suspended solids. The finishing waste water, in some plants, is metered back into the process water system with no reported adverse effects. The characteristics of waste waters produced by a number of insulation board plants are summarized in Table 44.

Chip Washing - As previously discussed, a chip washer is utilized by most plants using chips as furnish. The chip washer is used to remove grit, sand, and other trash which may cause difficulties in refining, excessive wear of refiner plates, and impair finished quality of the final product by allowing grit and sand to be formed into the mat. As was stated above, the primary source of pollutants at this point is soluble material leached from the wood. This material would normally dissolve during the refining and other process operations and become incorporated into the process white water stream. No accurate characteristics of chip washer discharge are available; however, it must be noted that this waste water represents merely a redistribution of pollutants in the process rather than an effluent requiring treatment and disposal.

Process White Water - The process white water accounts for over 95 percent of the waste load and flow from an insulation board plant. It is characterized by high quantities of BOD, COD, suspended solids, and dissolved solids as shown in Table 44.

The three major factors affecting process waste water quality are 1) the extent of steam pretreatment, 2) the types of product produced and additives employed, and 3) raw material species. The major source of dissolved organic material originates from the raw material. From one to three percent (on a dry weight basis) of wood is composed of water-soluble sugars stored as residual sap and, regardless of the type of refining or pretreatment utilized, these sugars enter the water to form a major source of BOD and COD. Furthermore, when thermo-mechanical pulping is employed, not only do the residual sugars enter the system but there will also occur decomposition products formed by the hydrolysis of the carbohydrates naturally occurring in the wood.

Basically, two phenomena occur during steaming. The first of these is the physically reversible thermo-softening of the hemicellulose and lignin components of the middle lamella. This

TABLE 44 TOTAL PLANT WASTEWATER FROM INSULATION BOARD

Plant No.	Production KKg/day	Flow l/KKg	BOD Kg/KKg	COD Kg/KKg	TS Kg/KKg	SS Kg/KKg	DS Kg/KKg
13	109	41,380	11.3	67.9	95.9	52.1	45.0
7(1)	813	14,118	11.6	49.0	--	11.8	20.4
9	163	11,564	15.1	--	--	14.1	—
12(1)	322	9,189	15.1	20.3	--	4.2	—
6(1)	142	50,494	27.5	--	--	14.5	—
15 (1)	227	8,346	32.3	62.5	48.1	11.7	36.3
5(1)	291	7,800	33.7	72.4	--	3.0	8.0
17	154	14,506	33.7	--	--	30.0	—
4	528	103,910	34.7	--	--	24.7	—
11(3)	457	--	35.2	181.8	278.9	235.0	—
1	200	45,487	39.0	94.5	93.9	10.5	83.4
10(4)	217	8,330	40.9	--	98.2	25.7	—
14	353	9.644	44.6	88.7	--	52.3	—
3(1)	154	19,956	valid	data	not	available	

(1) Analysis taken after preliminary clarification
(2) Forming machine production
(3) Plant utilizes bagasse
(4) Values do not represent present conditions due to experimental changes in water systems
(5) Represents 70-90 percent of total load

effect does not break down the cellulose or hemicellulose into water soluble substances.

The second effect consists of time dependent chemical reactions in which hemicellulose undergoes hydrolysis, and produces oligosaccharides (short chained, water soluble wood sugars, including disaccharides). In addition, hydrolysis of the acetyl groups form acetic acid. The resulting lowered pH causes an increase in the rate of hydrolysis. Thus, the reactions can be said to be autocatalytic. For this reason, the reaction rates are difficult to calculate. However, estimations have been made that the reaction rates double with an increase in temperature of eight to ten degrees Celsius. As can be expected and as shown in Figure 40 there is a higher BOD in a plant's waste water when the plant utilizes steaming. This results primarily from an increase in the dissolved substances entering the water. There is, however, not a direct relationship between the amount of BOD and the amount of dissolved solids entering the system. In general, at lower temperatures (pressures), where higher yields are found, there is a higher ratio of BOD to dissolved solids because of a higher percentage of low molecular weight material entering the waste water. This is illustrated in Figure 41. It can be concluded that with increased steam pressure there is a higher proportion of long chain, high molecular weight carbohydrates entering the water. These compounds are not easily biodegradable.

Plants 7, 9, 12, 13, and 16 in Table 44 all report little or no steaming of furnish and other than plant 4, which will be discussed later, the remainder of the plants steam a major portion of furnish.

The exact nature and percentage of materials dissolved in the water vary with species, i.e., as discussed earlier in this document, hardwoods contain a greater percentage of potentially soluble material than do softwoods. Nevertheless, as indicated in Table 45, using steam factors from Figure 40, the effect of species on waste water load is of secondary importance when compared to the degree of steaming to which the chips are subjected and to the extent of hardboard production.

An analysis of the data in Table 45 shows a correlation coefficient of 0.79 between the steam factor and BOD load data. Neglecting the data from plant 10, a correlation coefficient of 0.73 is observed between hardboard production of plants with high steam factors and BOD load. The fact that species type has relatively little effect on pollutant generation, or that what effect it does have is masked by the more significant effects of steaming and hardboard production, is shown by a correlation coefficient between the utilization of hardwood and BOD load of less than 0.1 for the types of plants that utilize little or no steaming and for plants with high steam factors.

While a large portion of the BOD in the process waste water is a result of organics leaching from the wood, a significant portion

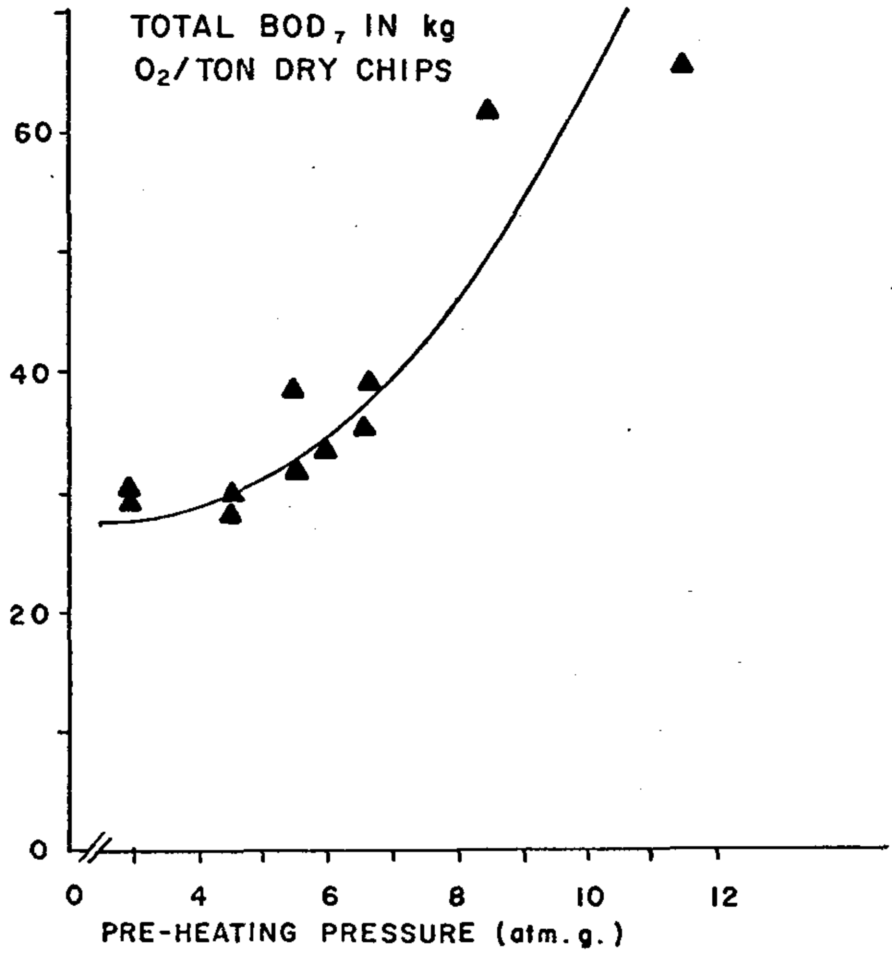


FIGURE 40 VARIATION OF BOD WITH PRE-HEATING PRESSURE

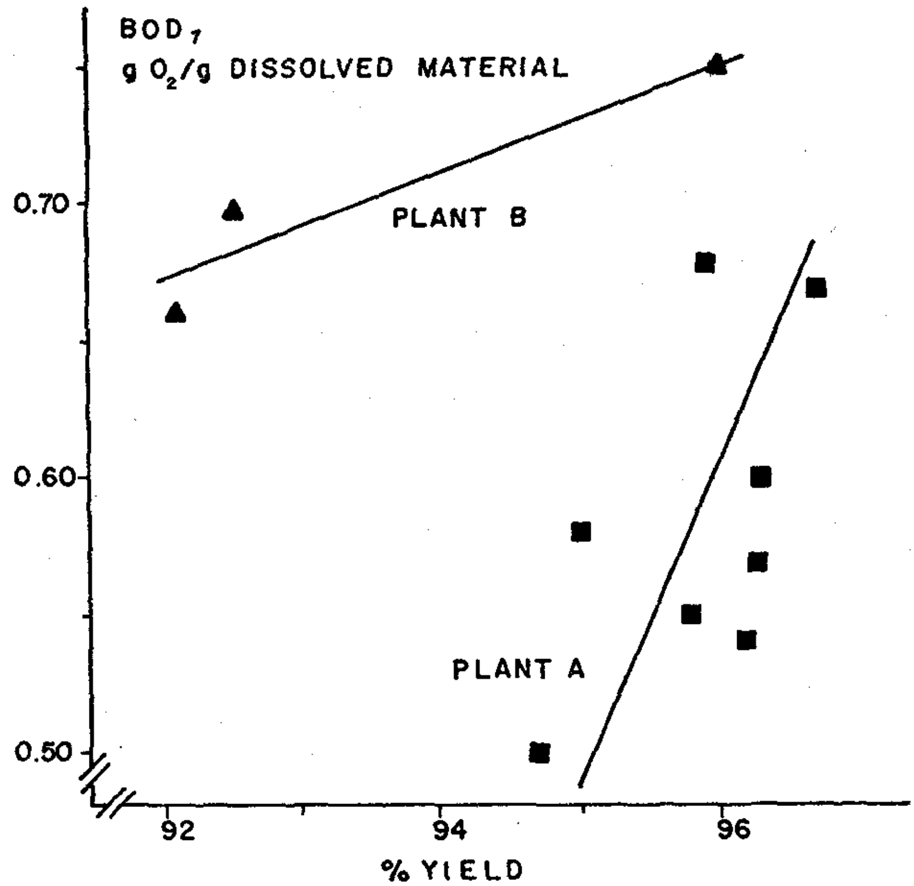


FIGURE 41 VARIATION OF THE RATIO OF BOD/DISSOLVED SOLIDS WITH YIELD

TABLE 45

EFFECT OF HARDWOOD, STEAMING, AND HARDBOARD PRODUCTION ON THE BOD LOAD FROM INSULATION BOARD PLANTS

Plant No.	Hardwood Percent Furnish	Steam Factor	Hardboard Percent Production	BOD Kg/KKg
16	10	2.5	0	6.5
13	0	2.7	0	11.2
7	15	2.5	0	11.6
9	0	3.6	0	15.1
12	22	3.8	0	15.1
6	0	6.0	0	27.6
15	56	6.5	0	32.2
17	100	6.2	0	33.6
5	15	9.0	27	33.6
4	92	4.0	44	34.7
1	100	6.0	60	39.0
10*	92	6.2	0	40.5
14	7	6.3	26	44.6
3	0	--	47	NG

*Values do not represent present conditions due to experimental changes in water systems.

results from additives. Additives vary in both type and quantity according to the operational preferences of the plant to some extent, but primarily to the type of product being produced. An unpublished report prepared by the Acoustical and Insulating Materials Association indicates a variation in waste load with variation in additives; however, this is difficult to quantify.

The three basic types of product produced by insulation board plants, sheathing, finished tile (ceiling tile, etc.), and hardboard (including medium density siding), receive various amounts of additives. Sheathing contains up to 25 percent additives which include asphalt, alum, starch, and size (either wax or resin). Finished tile contains up to 10 percent additives which are the same as used in sheathing, except no asphalt is used. Hardboard contains up to 30 percent additives including organic resins, as well as emulsions and tempering agents such as tall oil.

Total retention of these additives would be advantageous from both a production cost as well as waste water standpoint, but is not currently achievable. Therefore, the process waste water will contain not only leachates from the wood and fugitive fiber, but also the portion of the additives not retained in the product.

The primary effect of product type occurs with the production of hardboard in an insulation board plant. Hardboard often requires higher amounts of additives, but it also requires a pulp of a higher quality than does insulation board and thus more fiber preparation may be necessary. For these reasons, the hardboard producing plants will have a greater waste water load than plants which do not produce hardboard. This again is shown in Table 45. Plants 1, 3, 5, and 14 all utilize steaming in fiber preparation and also produce hardboard; therefore, these plants have characteristically higher waste water loads. Plant 4, which also produces hardboard, utilizes little or no steaming of furnish. For this reason, the effluent from plant 4 is similar to the effluents from plants that steam chips but do not produce hardboard.

Model Plants

As discussed in Section IV, the subcategory of insulation board production has been further subcategorized into two portions. Subcategory I consists of plants that do little or no steaming of furnish. These plants are 7, 9, 12, 13, and 16. Subcategory II includes those plants that steam the furnish or plants that produce hardboard at the same facility. These include plant numbers 1, 3, 4, 5, 6, 10, 14, 15, and 17 as shown in Table 44.

There are wide variations of production rates within each category; however, there is little or no correlation between production rates and subcategories. Since the average production rate for all plants listed in Table 44 is 288 metric tons per day (318 tons per day), a production rate of 270 metric tons per day

(300 tons per day) was selected as the production rate for all model plants.

An analysis of the data presented in Table 44 shows there is a wide range of waste water flow independent of subcategories. Waste water flow is not directly related to the organic waste water load discharged but to individual plant operation and water utilization practices. A flow of 12,500 l per metric ton (3,000 gal per ton) was judged to be representative of plants with good inplant control. Therefore, a flow of 12,500 l per metric ton (3,000 gal per ton) was selected as the flow from the model plants for each subcategory.

Table 44 also shows a wide range of suspended solids discharged independently of subcategories. The suspended solids concentrations in the waste water discharged from an insulation board plant depend on equipment utilized to remove suspended solids from the waste water stream possibly prior to its reuse. The model plant for each subcategory is assumed to utilize a primary clarifier for suspended solids removal. Primary clarification is an effective and common method of suspended solids removal in the insulation board industry. Data in Table 44 show that the suspended solids in the effluent from primary clarifiers in all three subcategories can be expected to average 10 kilograms per metric ton (20 pounds per ton).

The model plants are assumed to have adequate sludge handling facilities since this is the case for most existing plants. Based on limited data, it was assumed that the waste sludge from primary clarifiers is 10 kilograms per metric ton (20 pounds per ton) at 3.0 percent consistency.

The principal variation in waste water quality between subcategories occurs in regard to the BOD loads. The BOD loads for subcategory I and II were selected to be 12.5 kilograms per metric ton (25 pounds per ton), and 37.5 kilograms per metric ton (75 pounds per ton), respectively.

As shown in Table 44, the BOD loads in subcategory I range from 6.5 kilograms per metric ton to 15 kilograms per metric ton (13 pounds per ton to 30 pounds per ton). Plant 16, which has a discharge of 6.5 kilograms per metric ton (13 pounds per ton), soaks its wood before grinding; however, This operation will be phased out by the end of 1974. The soaking liquor removes a portion of the BOD load which is not reported as part of the 6.5 kilograms per metric ton (13 pounds per ton). This is assumed to be approximately 25 percent of the total plant discharge. An average of the adjusted BOD load for the subcategory. The plants in this subcategory exercise approximately equal degrees of inplant control methods.

The BOD of 37.5 kilograms per metric ton (75 pounds per ton) of subcategory II is considered reasonable based on interpretation of the data presented in Table 44. Waste loads from these plants range from 27.5 to 44.6 kilograms per metric ton (55 to 89 pounds per ton). Although little data is available, plant 10, which reports a waste load to 40.5 kilograms per metric ton (81 pounds per ton), appears to have reduced its waste load significantly at this time. Based on current experimental modifications at this plant, it is projected that the plant can reduce its waste load to 27.5 kilograms per metric ton (55 pounds per ton) or less. An average of the plants in this subcategory is approximately 37 kilograms per metric ton (74 pounds per ton); therefore, the BOD load for this subcategory was assumed to be 37 kilograms per metric ton (74 pounds per ton).

A summary of the waste water characteristics for model plants of all subcategories is presented below.

	Flow l/kkg	Production kkg/day	BOD kg/kkg	SS kg/kkg
I	12,500	270	12.5	10
II	12,500	270	37.5	10

It should be noted that the presented flows and loads occur after a primary clarifier. The loads and flows given do not include cooling water, boiler blowdown, roof runoff, yard runoff, or waters from raw material handling and storage operations.

PARTICLEBOARD

Specific Water Uses

There is little water used in the manufacturing of particleboard itself. Water usage for raw materials handling is typical of the timber products industries and is discussed elsewhere in this document. The water use within a typical plant may consist of that used for cleaning blenders, rinsing additive storage tanks, caul cooling sprays, mat sprays, fire suppression water, cooling water, water used in scrubbers for air emissions control, and water used in miscellaneous operations. The total quantity of waste water flow, excluding cooling water, from a particleboard plant, according to all collected data, may range from less than 190 lpd (50 gal per day) to as much as 320,000 lpd (86,000 gal per day), with little correlation in plant production. Cooling water requirements may run from 150 to 2,300 cu m per day (0.04 to 0.60 mgd), but rarely exceed 1,100 cu m per day (0.3 mgd). Table 46 itemizes waste water flows from particleboard plants. Data were obtained by questionnaires sent out by the National Particleboard Association and samples collected from several plants during this study.

Blender Wash: Blender cleaning is necessary because of the fact that during the operation of the blender there is a buildup of resin and wood particles on the interior of the machine which causes increased friction and eventual binding of the moving

TABLE 46

PARTICLEBOARD PLANT PROCESS WATER AND COOLING WATER FLOW RATES

Plant Number	Production (kkg/day)	Wastewater Discharge (l/day)	Cooling Water Discharge (l/day)	Blender Washout (l/day)	House-keeping (l/day)	Press Pit (l/day)	Storage Tank Wash Waters (l/day)
15	87 [7]	189		189			
1	18						76 [1]
29	54			189			
28	136		190,764	568 [1]			
25	136	227 [7]	151,400		151		76
2	140		187,887	57	802		303
23	261		2,180,160 [7]				
3	272	1,097,650 [6]	1,362,600 [4]			1893 [4]	
16	272	15,140					
4	295	12,301 [7]	55,658 [4] to 416,350		4273 [5] to 9463	1325	1514
31	297	327,213	163,512 to 464,798	54,504	218,016	54,693	
11	317	4542 [7]	654,048	189	76		189
17	317		545,040 [4]		1893 [7]		
6	336		11,355	1325			
20	356	3785	189,250	3785			
9	363		10,901 [7]	227 to 341			
5	363		43,603	7570	18,925 [2]		18,925 [3] l/change

TABLE 46

PARTICLEBOARD PLANT PROCESS WATER AND COOLING WATER FLOW RATES (Continued)

Plant Number	Production (kkg/day)	Wastewater Discharge (l/day)	Cooling Water Discharge (l/day)	Blender Washout (l/day)	House-keeping (l/day)	Press Pit (l/day)	Storage Tank Wash Waters (l/day)
30	381		253,595				
12	392		1,627,550				
26	431		98,032[4]			21,953	
27	449		2,180,160				
14	499	8327[7]	2,180,160	7570			757
19	635		1,771,380				
10	726						2839[3] l/wk
8	1361			Dry Clean			
32			454,200		18,925		

NOTE: No available data for plant numbers not listed.

1) once per week
2) once per 3-months
3) frequency varies
4) recycled
5) includes blender wash
6) scrubber effluent
7) estimated

parts of the blender, increased wear on the motors, and a decrease in blender capacity. Also the residue buildup on the inside of the blender may break loose and become formed into the finished board. This may result in resin spots which are considered by the industry to be a serious quality problem. This residue must be removed periodically. The volume of wash water used depends on (1) the frequency of cleaning, and (2) whether the cleaning operation is preceded by manual scraping of the blender. The frequency of the blender cleanup operation varies from plant to plant. Blenders may be cleaned as infrequently as once a week or as often as four times a day depending on the type of blender being used as well as the size of the wood particles and the tack (ability to adhere) of the resin being added.

Certain types of blenders are equipped with a cooling jacket which reduces the frequency of washing because the resins utilized are thermo-setting and a reduction in temperature inside the blender will significantly reduce the amount of buildup. There is a wide variation in buildup in actual field conditions. No definitive explanation for this variability in buildup is available. It has been noted in the field that particles of smaller size cause an increase in the rate of buildup on the interior of a blender. While no definitive studies have been conducted in this area, the phenomenon is most likely related to the surface area, volume ratio of the particles.

Blenders, although usually cleaned with water, are sometimes cleaned by manual scraping followed by the use of steam to remove the remainder of the waste. This method requires approximately 45 l (12 gal) of water per washing operation. When water is used to wash out blenders, the resulting quantity of water required is approximately 400 l (100 gal) per wash. A discussion of factors for choosing wet or dry blender cleaning can be found in Section VII of this report. When phenolic resins are used, they may be added in a refiner rather than in a blender; however, the refiners must also be cleaned and a waste stream of a similar volume results.

In a particleboard plant there is need occasionally to clean additive storage tanks to remove a buildup of residue. The amount of water used varies widely, approximately from 75 to 19,000 l (20 to 5,000 gal) per washing operation, but usually does not exceed 2,000 l (500 gal) per wash. These tanks are washed infrequently, usually once every three months for resin storage tanks and once a year for wax emulsion storage tanks. Some plants find the need to wash tanks more frequently for reasons relating to resin storage life and ambient temperatures. Also, washing is required more frequently when different types of resins used for different products must be stored in the same tank.

<u>Caul Cooling Water</u> - Approximately half the particleboard plants in the U. S. utilize cauls for forming the mat or transporting the mat into the press and the finished board out of the press. During the pressing cycle, the cauls may become quite warm and

must be cooled before being reused. This is usually accomplished by spraying a fine mist of water onto the cauls. There is usually no discharge from this point, and, if discharge does occur, it normally does not exceed 3.8 to 7.6 l (1 to 2 gal) per minute.

Mat Spray - In order to improve the final product, it is sometimes advantageous to slightly moisten the mat before it is pressed. This is done by a spray in a similar manner as caul cooling, and usually results in no discharge.

Fire Suppression Water - An inherent problem in the production of particleboard is that as a result of the wood particles being transported in a dry state, they are subject to fire and explosion. The interior of a particleboard plant can easily become coated with dry particles which are ignitable by an electrical spark or excessively hot press or other equipment. Most frequently fires start in a refiner or flaker and quickly spread throughout the particle conveying system. Fires are not scheduled and their frequency varies from mill to mill depending on the degree of particle preparation carried out and other factors. Historically, major fires occur from two to twelve times a year. Most mills have elaborate fire fighting systems which use massive quantities of water to rapidly extinguish fires. The quantity of water used will vary with the extent and duration of the fire. In addition, there are sometimes minor fires, occurring as often as once or twice a day but more commonly once or twice a week, which require relatively small quantities of water for control.

Cooling Water - The largest volume of water used in a particleboard mill is cooling water for various inplant equipment such as refiners, air compressors, hydraulic systems, press platens, resin tanks, blenders, and other machinery. As presented in Table 46, typical volumes vary from 150 cu m per day (0.04 million gal per day) to over 7,000 cu m per day (2.0 million gal per day).

Scrubbers - Air pollution from particleboard mills is a major environmental concern. One method of air pollution control in the particleboard industry is the use of wet scrubbers. Water usage for scrubbing will vary depending on the individual scrubber design. As discussed in Section VII, all of the waste water from wet scrubbers can be recycled by use of settling ponds with makeup being added to replace that evaporated. Excess solids buildup in the settling ponds is normally hauled to landfill areas as necessary. As most scrubbers in the particleboard industry can be operated without a waste water discharge, they are not considered to be a significant waste water source.

Miscellaneous Operations - There are several miscellaneous operations in a particleboard mill that result in waste water discharges totaling approximately 4,000 lpd (1,000 gal per day) per plant. These discharges consist primarily of water and oil formed in the press pit because of leaking of the press hydraulic system and water used for general plant cleanup. Volumes reported from the press pit vary from essentially zero to 54,700 lpd (14,450 gal per day); however, a flow of 1,000 lpd (300 gal per day) or less is judged to be typical. The plants reporting higher volumes usually rinse the press pit with water. Although many plants are cleaned with vacuum cleaners or other dry devices, some plants feel the need to wash these areas with water for the purpose of fire prevention. If this is done, there will be an increased water discharge of approximately 8,000 lpd(2,000 gal per day) from the plant.

Another water discharge may result from the condensation of steam coming into contact with the cold metal of a pressurized refiner during start up. This is an intermittent flow that will cease once the refinery reaches operating temperatures. The quantity is estimated to be less than 150 1 (40 gal) per startup per refiner.

Waste Water Flow and Concentrations

The limited amount of available data describing the characteristics of contaminated waste water generated by particleboard plants is presented in Table 47. It should be noted that (1) the concentrations listed in the table in most cases include dilution by cooling water and (2) considerable variations in the concentrations result from differences in operational procedures. An illustration of the latter factor may be made by observing that substantial amounts of waste water originate from housekeeping operations and, therefore, include various wash waters. The concentrations of pollutants in these waters are a direct function of the volume of water used in the cleanup operations, and the volume of water used, in turn, is a function of operator choice or equipment design.

Despite the lack of available data, the technology applicable to the control of waste waters from particleboard plants is dependent on waste water volumes rather than concentrations.

Blender Wash - Table 48 which presents characteristics of waste streams produced by blender washing in various plants indicates a wide variation among the plant waste water characteristics shown. As mentioned in the process descriptions in Section III, the two types of resins used in the particleboard industry are urea and phenolic based resins with urea resin being used in 90 percent or more of the cases. In addition, a catalyst may be added to urea resins to reduce cure time. The waste water from blender washings consists of various dilutions of the resins as well as wood particles. Urea resins have high nitrogen contents while phenolic resins contain high concentrations of phenols, and these parameters will appear in the respective waste waters.

Additive Storage Tank Wash - A waste stream generated by additive storage tank washing will contain various dilutions of additive resins as well as wax. The waste water from the wax washings

TABLE 47

TOTAL PARTICLEBOARD PLANT RAW WASTEWATER DISCHARGE

Plant No.	Flow (l/day)	pH	Color (units)	Temp. (°C)	BOD (mg/l)	COD (mg/l)	TS (mg/l)	SS (mg/l)	DS (mg/l)	PO4 (mg/l)	Phenols (mg/l)	Oil & Grease (mg/l)	TN (mg/l)	ON (mg/l)
4	12,491	7.2 to 12.0	380		115 to 44			35 to 260				17 to 18		
31	327,403			28	134 to 260	320		134 to 259		0.7	18.5		135	
12	264,950*	6.6	15		300	115	68	21	47		0			4.1
32		6.2 to 7.6	50	22 to 24	6 to 35			30				1 to 50		

*Total flow includes wastewater and some cooling water.

TABLE 48

WASTE WATER ANALYSIS BY STREAM

Source	Plant No.	Flow (l/day)	pH	Color (units)	Turb. (J.T.U.)	BOD_5 (mg/l)	COD (mg/l)	TS (mg/l)	SS (mg/l)	DS (mg/l)	ST.S (mg/l)	PO_4 (mg/l)	Phenols (mg/l)	TN (mg/l)	KN (mg/l)	VS (mg/l)	P (mg/l)	TOC (mg/l)
Blender Wash	24	379 37	6.4			60	357	373	98	275	<1	/	0.75		18.3			
	6	1325	7.0	433	5	31,500	9,523	4,385	1,650	2,735		1.67		1340				
Urea Resin Tank Wash	4	1514	7.7									15						
	11	189		262	750	39,300	18,200	38,234	3,335	34,899		6.75	87.4	41,278		34,534		
Press Pit	3	1893	7.4			500	13,200	5,638	155	5,483	<1		35		52.2	5,079	3.14	
	5	95	7.3			150	414	697	225	472			<.005		64.5		1.85	148

will contain quantities of floatable wax. The waters from washing resin tanks will contain quantities of nitrogen or phenols, depending on whether urea or phenolic resins are utilized.

Cooling Water - Cooling water is usually uncontaminated and is characterized by having an increased temperature that will vary with the type of equipment being cooled. However, in some cases, mills handling their cooling water in open trenches allow the cooling water to become contaminated with wood fibers, additives, or oil. Generally, it is considered that proper process management allows cooling water to be a noncontact, uncontaminated stream.

Miscellaneous Operations - The waste stream generated by general plant cleanup or waters pumped from the press pit vary widely in degree of contamination. The water from plant cleanup will normally contain wood particles as well as some oils or resins which have been spilled. The amounts of these substances in the waste water stream will vary considerably with time. The waste stream from the press pit is composed of liquids from the hydraulic system of the press as well as from steam lines and will contain a large amount of fugitive particles. Characteristics of this stream vary. Results of analyses conducted for one plant are presented in Table 48.

Model Plant

Based on the values presented in Table 46, a typical particleboard plant discharges on an intermittent basis 11,000 l (3,000 gal) per day of contaminated waste water. It has a production of 270 metric tons (300 tons) per day. The 22,000 l (3,000 gal) of waste water consist of 7,200 l (2,000 gal) per day of housekeeping water, i.e., water used for general plant cleanup; 1,900 l (500 gal) per day of resin blender wash water; and an additional 1,900 l (500 gal) per day consisting of miscellaneous flows including periodic washdown of storage tanks, pressurized refiner start-up, and water from the press pit. It is felt that because no discharge is a feasible alternative, the flow is the primary factor involved in a consideration of waste water treatment schemes. The model plant utilizes planer shavings or chips as a basic raw material. It does not wash the raw material before utilizing it in the process.

The model plant is considered to be typical of the particleboard industry at this time. However, the model plant in the future may include both a chip washer and a scrubber for air emissions control.

FINISHING OPERATIONS

There are two distinct classifications of finishing materials used in the factory finishing of wood products. Liquid finishing materials include water and solvent based sealers, stains, dyes, primers, fillers, base or ground coatings, printing inks, and top coatings. Overlaying materials include resin-impregnated papers, special plastic films, and metal foils. The overlaying of particleboard with veneers and hardboard is also practiced to a limited extent.

The water used in finishing operations primarily consists of makeup water and wash water associated with the use of water-reducible coatings and adhesives and in surface cleaning operations practiced at some plants as an initial step in the finishing operation. As reported by Tomsu, the use of water-base coatings has been associated with the increasingly stringent regulatory limits on solvent emissions from finishing lines. Water-base fillers are used on particleboard, hardboard, and open-grained plywood. Water thinned sealers, ground coats, and clear top coats are also used to some extent. Some finishing plants prepare the surface of the substrate for finishing by machine washing with water and a mild detergent. However, such an operation produces no waste water as all wash water is used in the makeup of the cleaning solution.

The only sources of waste water from finishing operations result from the washing of equipment associated with the use of water-reducible coatings and water soluble adhesives. Such equipment includes the various types of applicating machines discussed in Section III and the vats or barrels in which the coating materials or adhesives are mixed and stored prior to application.

Table 49 shows the total volumes of waste water generated at several finishing plants. Also given in this table are the types of finished products produced, annual production rates, and the types of water reducible materials applied at each plant. It can be seen that the volumes of waste water generated vary considerably from plant to plant. These variations are chiefly attributable to the different manners in which the equipment is washed. For instance, some plants may use 90 to 115 l (25 to 30 gal) of water or more to wash down one roll coater used in applying a water base coating material, while another plant may use less than 20 l (5 gal) of water to wash down the same type of machine used to apply a similar type of material.

Because of the wide variety of finished products produced, types of coatings applied, and methods of application and drying employed, both water and solvent base coating materials are custom formulated for each application. The constituents of these materials are widely varied throughout the industry and in many cases even at the individual finishing plant level where custom formulations are freqently made. Generally, as reported by Leary, the market requirement influences the type of chemical coating system applied to the surface of any finished product.

Because of such extreme variations, no list of typical ingredients of coating materials used in wood finishing is available, and characterization of the waste waters generated in the use of such materials is not possible on an industry wide basis. Characterization of waste waters from such finishing

TABLE 49

WASTE WATER GENERATION FROM FINISHING PLANTS

Plant	Type of Finished Products Produced	Annual Production of Finished Products (Millions of Square Meters)	Applicators of Water-Reducible Finishing Materials	Volumes of Wastewater Generated*
A	Prefinished Wall Paneling and Vinyl Overlaid Hardwood Plywood	12	1 Groove Striper 1 Adhesive Spreader (Direct Roll)	260
B	Prefinished Wall Paneling	11	2 Filler Applicators (Reverse Roll) 2 Groove Stripers	1,360
C	Prefinished Wall Paneling	6	1 Grain Printer (2 Rolls)	75
D	Prefinished Wall Paneling	2	1 Top Coater (Direct Roll) 1 Sealter Coater (Direct Roll)	110
E	Vinyl Overlaid Hardboard Panels	4	1 Adhesive Spreader (Direct Roll)	75
F	Prefinished Wall Paneling	11	1 Sealer Coater (Direct Roll)	110
G	Prefinished Wall Paneling	9	3 Sealer Coaters (Direct Roll)	170
H	Prefinished Wall Paneling	10	1 Sealer Coater (Direct Roll) 1 Filler Coater (Reverse Roll)	760
J	Aluminum Overlaid Softwood Plywood Exterior Siding	--	1 Adhesive Spreader 2 Spray Booths	450

*Liters

operations would only be possible on an individual plant basis. Table 50 shows the results of the chemical analyses of several water base coatings and the wash waters generated from their use. However, these materials are not typical of all waterbase coating materials used in finishing operations and are presented only as an indication of possible waste water characteristics.

As reported by Conner, various metals may find their way into any coating material. Additives of various types such as those which are incorporated into a coating material as stabilizers for such purposes as to prevent biological contamination of the material during its shelf-life, often contain mercury, although at the present time efforts are being made by the paint and coating industry to develop additives of non-mercuric types. Pigments incorporated into a coating material to provide color, commonly contain lead or cadmium or other materials.

The most extensive study of waste water from paints and coatings is currently being made for EPA by Southern Research Institute. The findings of this study with respect to waste water characteristics of waste water from water-base paints and coatings would be most representative of the waste waters generated from finishing operations in the timber products processing industry which involve the use of such materials.

Adhesives used in overlaying various sheet materials include plastic and vinyl films, medium density impregnated papers, and metal foils. The most commonly used adhesives for overlaying special plastic films are polyvinyl acetate water-emulsion adhesives, solvent-type elastomeric adhesives, modified phenolic films, special epoxy-resin formulations, and various contact-type adhesives. The resin-impregnated papers requiring additional adhesive bonding are commonly bonded to the wood substrate by phenolic and modified phenolic resin glues. Aluminum foil overlays are commonly applied with modified phenolic resin film glues, resorcinol resins, and rubber-base contact cements. As reported by Brumbaugh, phenol and urea resin glues are the most common adhesives used in overlaying veneers and hardboard onto particleboard. Of these various adhesives, only the polyvinyl acetate-water emulsions, the phenolic and urea resins, and the resorcinol resins are water soluble and would constitute a source of waste water in the washing of equipment associated with their use. Water-soluble adhesive applicating machines employed in overlaying operations are usually washed at the end of each run and require about 75 l (20 gal) of water for each washing.

Since most overlayed wood products are usually produced as specialty items in the larger finishing plants, and are not usually produced on a full scale, continuous production basis, volumes of waste water generated from such operations would seldom exceed 75 lpd (20 gal per day) from any single finishing plant. The characteristics of these waste waters would be similar to those described previously for adhesive wash waters generated in fabricating operations. The chemical analysis of a

TABLE 50

CHEMICAL ANALYSIS OF WATER BASE MATERIALS

Material	Total Solids (mg/l)	Total Suspended Solids (mg/l)	Total Dissolved Solids (mg/l)	Total Volatile Solids (mg/l)	Total Suspended Solids (mg/l)	Total Dissolved Solids (mg/l)	COD (mg/l)	PO4t (mg/l)	Nt (mg/l)	Phenols (mg/l)
Water base sealer	267,805	56,465	211,340	196,866	40,755	156,111	306,740	6351.0	469.56	3699.4
Washwater	1,765	335	1,430	1,405	141	1,264	8,428	191.9	123.31	104.0
Water base sealer	543,160	345,490	197,670	446,590	318,590	128,000	512,462	3500.0	435.44	329.4
Washwater	46,710	43,022	3,688	40,880	37,407	3,473	51,169	504.1	65.52	92.8
Water base sealer	675,530	538,530	137,000	203,970	146,370	57,600	305,760	137.8	89.82	4975.4
Washwater	28,300	25,537	2,763	7,510	5,420	2,090	26,264	86.5	6.33	212.1
Waterbase filler	1,203,720	1,160,290	43,430	223,720	154,150	69,570	226,968	113.5	579.44	361.3
Washwater	65,000	60,210	4,790	27,000	22,717	4,283	51,156	52.7	81.62	213.8
Water Soluble adhesives	607,771	88,098	519,673	591,167	77,566	513,601	807,128	94.6	77.25	2678.3
Washwater	253,502	250,492	3,010	241,342	238,656	2,686	245,000	1216.2	8.84	3191.1

water soluble adhesive used in a vinyl overlaying operation and the waste water generated from its use is presented in Table 50.

Figure 42 shows a process flow diagram for the production of printed grain, prefinished wall paneling and shows the amounts of waste water generated from such an operation. Although this may not be typical of any particular plant, it should serve here to illustrate typical sources and volumes of waste water that might be generated from such a plant.

Model Plant

Although finishing operations are carried out in many different types of plants, producing a wide variety of types of finished products, the volumes of waste water generated from finishing plants generally fall into the range of 75 to 1,100 lpd (20 to 300 gal per day). The typical finishing plant to be developed for the purposes for this study is a plant producing prefinished wall paneling with a total waste water generation of 750 lpd (200 gal per day) resulting from the washing of equipment associated with the use of water-base finishing materials. The typical plant is assumed to consist of the following:

1. Two identical finishing lines similar to that shown in Figure 42.

2. Both lines operate on a 24 hour per day, 5 days per week basis.

3. Each line consists of three water-base material applicating machines.

4. Annual production of prefinished paneling is equal to 10 million sq m on a 6.35 mm basis (107.6 million sq ft on a 0.25 in basis).

Typically, each water-base material applicating machine would be washed once each day requiring 75 l (20 gal) of water per wash. Wash water from machine wash down would then consist of 450 l (120 gal) per day. Material storage and mixing vats require 300 l (80 gal) of wash water per day. The total volume of waste water generated at the typical plant would then be 750 lpd (200 gal per day).

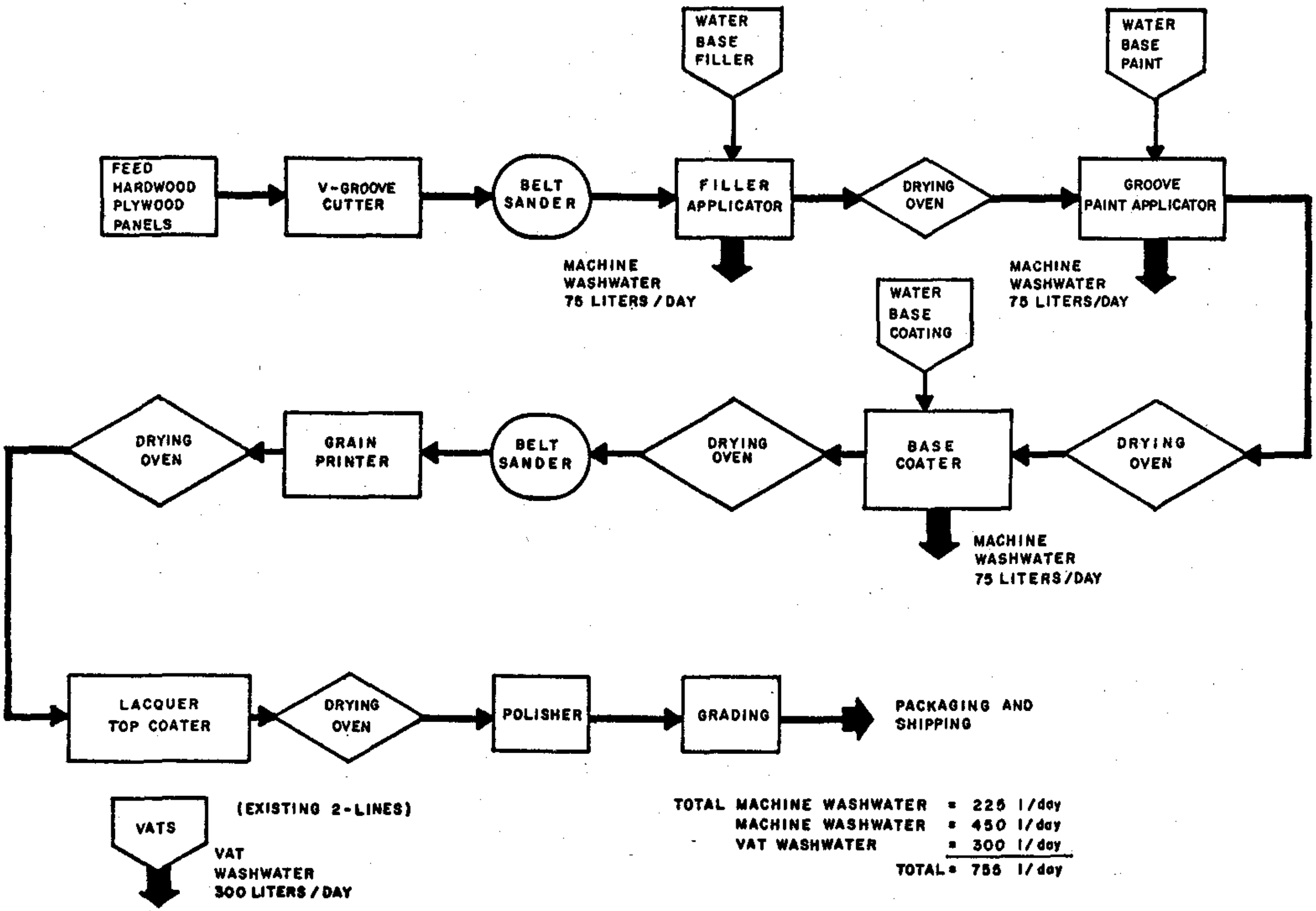


FIGURE 42 WASTEWATER PRODUCTION IN A PREFINISHED PANEL PLANT

SECTION VI

POLLUTANT PARAMETERS

Presented below is a discussion of pollutants and pollutant parameters that may be present in process waters in the portion of the timber products processing industry that is the subject of this proposed effluent guidelines and standards development document.

Certain of these parameters are common to all the subcategories covered by this document, although the concentrations in the process water and the absolute amounts generated per unit of production vary considerably among the subcategories.

Review of published information, Refuse Act Permit applications, industry data, and information generated during the survey and analysis phase of this effluent guidelines development program determined that the following pollutants or pollutant parameters may be common to all of the subcategories:

Biochemical Oxygen Demand (BOD5)
Chemical Oxygen Demand
Phenols
Oil and Grease
pH
Temperature
Dissolved Solids
Total Suspended Solids
Phosphorus
Ammonia
Copper
Chromium
Arsenic
Zinc
Flourides

The above listed pollutants or pollutant parameters are, of course, not present in process water from all the subcategories for which effluent guidelines and standards are presented in this document. Their presence depends on a number of factors, such as processing method, raw materials used, and chemicals added to the process.

Following is a discussion of the significant pollutants and pollutant parameters.

Biochemical Oxygen Demand (BOD5)

Biochemical oxygen demand (BOD) is a measure of the oxygen consuming capabilities of organic matter. The BOD does not in itself cause direct harm to a water system, but it does exert an indirect effect by depressing the oxygen content of the water. Sewage and other organic effluents during their processes of decomposition exert a BOD, which can have a catastrophic effect on the ecosystem by depleting the oxygen supply. Conditions are reached frequently where all of the oxygen is used and the continuing decay process causes the production of noxious gases such as hydrogen sulfide and methane. Water with a high BOD indicates the presence of decomposing organic matter and subsequent high bacterial counts that degrade its quality and potential uses.

Dissolved oxygen (DO) is a water quality constituent that, in appropriate concentrations, is essential not only to keep organisms living but also to sustain species reproduction, vigor, and the development of populations. Organisms undergo stress at reduced DO concentrations that make them less competitive and able to sustain their species within the aquatic environment. For example, reduced DO concentrations have been shown to interfere with fish population through delayed hatching of eggs, reduced size and vigor of embryos, production of deformities in young, interference with food digestion, acceleration of blood clotting, decreased tolerance to certain toxicants, reduced food efficiency and growth rate, and reduced maximum sustained swimming speed. Fish food organisms are likewise affected adversely in conditions with suppressed DO. Since all aerobic aquatic organisms need a certain amount of oxygen, the consequences of total lack of dissolved oxygen due to a high BOD can kill all inhabitants of the affected area.

If a high BOD is present, the quality of the water is usually visually degraded by the presence of decomposing materials and algae blooms due to the uptake of degraded materials that form the foodstuffs of the algal populations.

Phenols

Phenols and phenolic wastes are derived from petroleum, coke, and chemical industries; wood distillation; and domestic and animal wastes. Many phenolic compounds are more toxic than pure phenol; their toxicity varies with the combinations and general nature of total wastes. The effect of combinations of different phenolic compounds is cumulative.

Phenols and phenolic compounds are both acutely and chronically toxic to fish and other aquatic animals. Also, chlorophenols produce an unpleasant taste in fish flesh that destroys their recreational and commercial value.

It is necessary to limit phenolic compounds in raw water used for drinking water supplies, as conventional treatment methods used by water supply facilities do not remove phenols. The ingestion of concentrated solutions of phenols will result in severe pain, renal irritation, shock and possibly death.

Phenols also reduce the utility of water for certain industrial uses, notably food and beverage processing, where it creates unpleasant tastes and odors in the product.

Oil and Grease

Oil and grease exhibit an oxygen demand. Oil emulsions may adhere to the gills of fish or coat and destroy algae or other plankton. Deposition of oil in the bottom sediments can serve to exhibit normal benthic growths, thus interrupting the aquatic food chain. Soluble and emulsified material ingested by fish may taint the flavor of the fish flesh. Water soluble components may exert toxic action on fish. Floating oil may reduce the re-aeration of the water surface and in conjunction with emulsified oil may interfere with photosynthesis. Water insoluble components damage the plumage and coats of water animals and fowls. Oil and grease in a water can result in the formation of objectionable surface slicks preventing the full aesthetic enjoyment of the water.

Oil spills can damage the surface of boats and can destroy the aesthetic characteristics of beaches and shorelines.

pH, Acidity and Alkalinity

Acidity and alkalinity are reciprocal terms. Acidity is produced by substances that yield hydrogen ions upon hydrolysis and alkalinity is produced by substances that yield hydroxyl ions. The terms "total acidity" and "total alkalinity" are often used to express the buffering capacity of a solution. Acidity in natural waters is caused by carbon dioxide, mineral acids, weakly dissociated acids, and the salts of strong acids and weak bases. Alkalinity is caused by strong bases and the salts of strong alkalies and weak acids.

The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. Lower pH values indicate acidity while higher values indicate alkalinity. The relationship between pH and acidity or alkalinity is not necessarily linear or direct.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add such constituents to drinking water as iron, copper, zinc, cadmium and lead. The hydrogen ion concentration can affect the "taste" of the water. At a low pH water tastes "sour." The bactericidal effect of chlorine is weakened as the pH increases, and it is advantageous to keep the pH close to 7. This is very significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Dead fish, associated algal blooms, and foul stenches are aesthetic liabilities of any waterway. Even moderate changes from "acceptable" criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. Metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. The availability of many nutrient substances varies with the alkalinity and acidity. Ammonia is more lethal with a higher pH.

The lacrimal fluid of the human eye has a pH of approximately 7.0 and a deviation of 0.1 pH unit from the norm may result in eye irritation for the swimmer. Appreciable irritation will cause severe pain.

Temperature

Temperature is one of the most important and influential water quality characteristics. Temperature determines those species that may be present; it activates the hatching of young, regulates their activity, and stimulates or suppresses their growth and development; it attracts, and may kill when the water becomes too hot or becomes chilled too suddenly. Colder water generally suppresses development. Warmer water generally accelerates activity and may be a primary cause of aquatic plant nuisances when other environmental factors are suitable.

Temperature is a prime regulator of natural processes within the water environment. It governs physiological functions in organisms and, acting directly or indirectly in combination with other water quality constituents, it affects aquatic life with each change. These effects include chemical reaction rates, enzymatic functions, molecular movements, and molecular exchanges between membranes within and between the physiological systems and the organs of an animal.

Chemical reaction rates vary with temperature and generally increase as the temperature is increased. The solubility of gases in water varies with temperature. Dissolved oxygen is decreased by the decay or decomposition of dissolved organic substances and the decay rate increases as the temperature of the water increases reaching a maximum at about 30°C (86°F). The temperature of stream water, even during summer, is below the optimum for pollution-associated bacteria. Increasing the water temperature increases the bacterial multiplication rate when the environment is favorable and the food supply is abundant.

Reproduction cycles may be changed significantly by increased temperature because this function takes place under restricted temperature ranges. Spawning may not occur at all because temperatures are too high. Thus, a fish population may exist in a heated area only by continued immigration. Disregarding the decreased reproductive potential, water temperatures need not reach lethal levels to decimate a species. Temperatures that favor competitors, predators, parasites, and disease can destroy a species at levels far below those that are lethal.

Fish food organisms are altered severely when temperatures approach or exceed 90°F. Predominant algal species change, primary production is decreased, and bottom associated organisms may be depleted or altered drastically in numbers and distribution. Increased water temperatures may cause aquatic plant nuisances when other environmental factors are favorable.

Synergistic actions of pollutants are more severe at higher water temperatures. Given amounts of domestic sewage, refinery wastes, oils, tars, insecticides, detergents, and fertilizers more rapidly deplete oxygen in water at higher temperatures, and the respective toxicities are likewise increased.

When water temperatures increase, the predominant algal species may change from diatoms to green algae, and finally at high temperatures to blue-green algae, because of species temperature preferentials. Blue-green algae can cause serious odor problems. The number and distribution of benthic organisms decreases as water temperatures increase above 90°F, which is close to the tolerance limit for the population. This could seriously affect certain fish that depend on benthic organisms as a food source.

The cost of fish being attracted to heated water in winter months may be considerable, due to fish mortalities that may result when the fish return to the cooler water.

Rising temperatures stimulate the decomposition of sludge, formation of sludge gas, multiplication of saprophytic bacteria and fungi (particularly in the presence of organic wastes), and the consumption of oxygen by putrefactive processes, thus affecting the esthetic value of a water course.

In general, marine water temperatures do not change as rapidly or range as widely as those of freshwaters. Marine and estuarine fishes, therefore, are less tolerant of temperature variation. Although this limited tolerance is greater in estuarine than in open water marine species, temperature changes are more important to those fishes in estuaries and bays than to those in open marine areas, because of the nursery and replenishment functions of the estuary that can be adversely affected by extreme temperature changes.

<u>Dissolved Solids</u>

In natural waters the dissolved solids consist mainly of carbonates, chlorides, sulfates, phosphates, and possibly nitrates of calcium, magnesium, sodium, and potassium, with traces of iron, manganese and other substances.

Many communities in the United States and in other countries use water supplies containing 2000 to 4000 mg/l of dissolved salts, when no better water is available. Such waters are not palatable, may not quench thirst, and may have a laxative action on new users. Waters containing more than 4000 mg/l of total salts are generally considered unfit for human use, although in hot climates such higher salt concentrations can be tolerated whereas they could not be in temperate climates. Waters containing 5000 mg/l or more are reported to be bitter and act as bladder and intestinal irritants. It is generally agreed that the salt concentration of good, palatable water should not exceed 500 mg/l.

Limiting concentrations of dissolved solids for fresh-water fish may range from 5,000 to 10,000 mg/l, according to species and prior acclimatization. Some fish are adapted to living in more saline waters, and a few species of fresh-water forms have been found in natural waters with a salt concentration of 15,000 to 20,000 mg/l. Fish can slowly become acclimatized to higher salinities, but fish in waters of low salinity cannot survive sudden exposure to high salinities, such as those resulting from discharges of oil-well brines. Dissolved solids may influence the toxicity of heavy metals and organic compounds to fish and other aquatic life, primarily because of the antagonistic effect of hardness on metals.

Waters with total dissolved solids over 500 mg/l have decreasing utility as irrigation water. At 5,000 mg/l water has little or no value for irrigation.

Dissolved solids in industrial waters can cause foaming in boilers and cause interference with cleaness, color, or taste of many finished products. High contents of dissolved solids also tend to accelerate corrosion.

Specific conductance is a measure of the capacity of water to convey an electric current. This property is related to the total concentration of ionized substances in water and water temperature. This property is frequently used as a substitute method of quickly estimating the dissolved solids concentration.

Total Suspended Solids

Suspended solids include both organic and inorganic materials. The inorganic components include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, animal and vegetable fats, various fibers, sawdust, hair, and various materials from sewers. These solids may settle out rapidly and bottom deposits are often a mixture of both organic and inorganic solids. They adversely affect fisheries by covering the bottom of the stream or lake with a blanket of material that destroys the fish-food bottom fauna or the spawning ground of fish. Deposits containing organic materials may deplete bottom oxygen supplies and produce hydrogen sulfide, carbon dioxide, methane, and other noxious gases.

In raw water sources for domestic use, state and regional agencies generally specify that suspended solids in streams shall not be present in sufficient concentration to be objectionable or to interfere with normal treatment processes. Suspended solids in water may interfere with many industrial processes, and cause foaming in boilers, or encrustations on equipment exposed to water, especially as the temperature rises. Suspended solids are undesirable in water for textile industries; paper and pulp; beverages; dairy products; laundries; dyeing; photography;

cooling systems, and power plants. Suspended particles also serve as a transport mechanism for pesticides and other substances which are readily sorbed into or onto clay particles.

Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These settleable solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration and impair the photosynthetic activity of aquatic plants.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often much more damaging to the life in water, and they retain the capacity to displease the senses. Solids, when transformed to sludge deposits, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic and therefore decomposable nature, solids use a portion or all of the dissolved oxygen available in the area. Organic materials also serve as a seemingly inexhaustible food source for sludgeworms and associated organisms.

Turbidity is principally a measure of the light absorbing properties of suspended solids. It is frequently used as a substitute method of quickly estimating the total suspended solids when the concentration is relatively low.

Phosphorus

During the past 30 years, a formidable case has developed for the belief that increasing standing crops of aquatic plant growths, which often interfere with water uses and are nuisances to man, frequently are caused by increasing supplies of phosphorus. Such phenomena are associated with a condition of accelerated eutrophication or aging of waters. It is generally recognized that phosphorus is not the sole cause of eutrophication, but there is evidence to substantiate that it is frequently the key element in all of the elements required by fresh water plants and is generally present in the least amount relative to need. Therefore, an increase in phosphorus allows use of other, already present, nutrients for plant growths. Phosphorus is usually described, for this reasons, as a "limiting factor."

When a plant population is stimulated in production and attains a nuisance status, a large number of associated liabilities are immediately apparent. Dense populations of pond weeds make swimming dangerous. Boating and water skiing and sometimes fishing may be eliminated because of the mass of vegetation that serves as an physical impediment to such activities. Plant populations have been associated with stunted fish populations and with poor fishing. Plant nuisances emit vile stenches, impart tastes and odors to water supplies, reduce the efficiency of industrial and municipal water treatment, impair aesthetic beauty, reduce or restrict resort trade, lower waterfront property values, cause skin rashes to man during water contact, and serve as a desired substrate and breeding ground for flies.

Phosphorus in the elemental form is particularly toxic, and subject to bioaccumulation in much the same way as mercury. Colloidal elemental phosphorus will poison marine fish (causing skin tissue breakdown and discoloration). Also, phosphorus is capable of being concentrated and will accumulate in organs and soft tissues. Experiments have shown that marine fish will concentrate phosphorus from water containing as little as 1 ug/l.

Ammonia

Ammonia is a common product of the decomposition of organic matter. Dead and decaying animals and plants along with human and animal body wastes account for much of the ammonia entering the aquatic ecosystem. Ammonia exists in its non-ionized form only at higher pH levels and is the most toxic in this state. The lower the pH, the more ionized ammonia is formed and its toxicity decreases. Ammonia, in the presence of dissolved oxygen, is converted to nitrate (NO_3) by nitrifying bacteria. Nitrite (NO_2), which is an intermediate product between ammonia and nitrate, sometimes occurs in quantity when depressed oxygen conditions permit. Ammonia can exist in several other chemical combinations including ammonium chloride and other salts.

Nitrates are considered to be among the poisonous ingredients of mineralized waters, with potassium nitrate being more poisonous than sodium nitrate. Excess nitrates cause irritation of the mucous linings of the gastrointestinal tract and the bladder; the symptoms are diarrhea and diuresis, and drinking one liter of water containing 500 mg/l of nitrate can cause such symptoms.

Infant methemoglobinemia, a disease characterized by certain specific blood changes and cyanosis, may be caused by high nitrate concentrations in the water used for preparing feeding formulae. While it is still impossible to state precise concentration limits, it has been widely recommended that water containing more than 10 mg/l of nitrate nitrogen (NO_3-N) should not be used for infants. Nitrates are also harmful in fermentation processes and can cause disagreeable tastes in beer. In most natural water the pH range is such that ammonium ions (NH_4^+) predominate. In alkaline waters, however, high concentrations of un-ionized ammonia in undissociated ammonium hydroxide increase the toxicity of ammonia solutions. In streams polluted with sewage, up to one half of the nitrogen in the sewage may be in the form of free ammonia, and sewage may carry up to 35 mg/l of total nitrogen. It has been shown that at a level of 1.0 mg/l un-ionized ammonia, the ability of hemoglobin to combine with oxygen is impaired and fish may suffocate. Evidence indicates that ammonia exerts a considerable toxic effect on all aquatic life within a range of less than 1.0 mg/l to 25 mg/l, depending on the pH and dissolved oxygen level present.

Ammonia can add to the problem of eutrophication by supplying nitrogen through its breakdown products. Some lakes in warmer climates, and others that are aging quickly are sometimes limited by the nitrogen available. Any increase will speed up the plant growth and decay process.

Copper

Copper salts occur in natural surface waters only in trace amounts, up to about 0.05 mg/l, so that their presence generally is the result of pollution. This is attributable to the corrosive action of the water on copper and brass tubing, to industrial effluents, and frequently to the use of copper compounds for the control of undesirable plankton organisms.

Copper is not considered to be a cumulative systemic poison for humans, but it can cause symptoms of gastroenteritis, with nausea and intestinal irritations, at relatively low dosages. The limiting factor in domestic water supplies is taste. Threshold concentrations for taste have been generally reported in the range of 1.0-2.0 mg/l of copper, while as much as 5-7.5 mg/l makes the water completely unpalatable.

The toxicity of copper to aquatic organisms varies significantly, not only with the species, but also with the physical and chemical characteristics of the water, including temperature, hardness, turbidity, and carbon dioxide content. In hard water, the toxicity of copper salts is reduced by the precipitation of copper carbonate or other insoluble compounds. The sulfates of copper and zinc, and of copper and cadmium are synergistic in their toxic effect on fish.

Copper concentrations less than 1 mg/l have been reported to be toxic, particularly in soft water, to many kinds of fish, crustaceans, mollusks, insects, phytoplankton and zooplankton. Concentrations of copper, for example, are detrimental to some oysters above .1 ppm. Oysters cultured in sea water containing 0.13-0.5 ppm of copper deposited the metal in their bodies and became unfit as a food substance.

Chromium

Chromium, in its various valence states, is hazardous to man. It can produce lung tumors when inhaled and induces skin sensitizations. Large doses of chromates have corrosive effects on the intestinal tract and can cause inflammation of the kidneys. Levels of chromate ions that have no effect on man appear to be so low as to prohibit determination to date.

The toxicity of chromium salts toward aquatic life varies widely with the species, temperature, pH, valence of the chromium, and synergistic or antagonistic effects, especially that of hardness.

Fish are relatively tolerant of chromium salts, but fish food organisms and other lower forms of aquatic life are extremely sensitive. Chromium also inhibits the growth of algae.

In some agricultural crops, chromium can cause reduced growth or death of the crop. Adverse effects of low concentrations of chromium on corn, tobacco and sugar beets have been documented.

Arsenic

Arsenic is found to a small extent in nature in the elemental form. It occurs mostly in the form of arsenites of metals or as pyrites.

Arsenic is normally present in sea water at concentrations of 2 to 3 ug/l and tends to be accumulated by oysters and other shellfish. Concentrations of 100 mg/kg have been reported in certain shellfish. Arsenic is a cumulative poison with long-term chronic effects on both aquatic organisms and on mammalian species and a succession of small doses may add up to a final lethal dose. It is moderately toxic to plants and highly toxic to animals especially as AsH_3.

Arsenic trioxide, which also is exceedingly toxic, was studied in concentrations of 1.96 to 40 mg/l and found to be harmful in that range to fish and other aquatic life. Work by the Washington Department of Fisheries on pink salmon has shown that at a level of 5.3 mg/l of As_2O_3 for 8 days was extremely harmful to this species; on mussels, a level of 16 mg/l was lethal in 3 to 16 days.

Severe human poisoning can result from 100 mg concentrations, and 130 mg has proved fatal. Arsenic can accumulate in the body faster than it is excreted and can build to toxic levels, from small amounts taken periodically through lung and intestinal walls from the air, water and food.

Arsenic is a normal constituent of most soils, with concentrations ranging up to 500 mg/kg. Although very low concentrations of arsenates may actually stimulate plant growth, the presence of excessive soluble arsenic in irrigation waters will reduce the yield of crops, the main effect appearing to be the destruction of chlorophyll in the foliage. Plants grown in water containing one mg/l of arsenic trioxides showed a blackening of the vascular bundles in the leaves. Beans and cucumbers are very sensitive, while turnips, cereals, and grasses are relatively resistant. Old orchard soils in Washington that contained 4 to 12 mg/kg of arsenic trioxide in the top soil were found to have become unproductive.

Zinc

Occurring abundantly in rocks and ores, zinc is readily refined into a stable pure metal and is used extensively for galvanizing, in alloys, for electrical purposes, in printing plates, for dye-manufacture and for dyeing processes, and for many other industrial purposes. Zinc salts are used in paint pigments, cosmetics, pharmaceuticals, dyes, insecticides, and other products too numerous to list herein. Many of these salts (e.g., zinc chloride and zinc sulfate) are highly soluble in water; hence it is to be expected that zinc might occur in many industrial wastes. On the other hand, some zinc salts (zinc carbonate, zinc oxide, zinc sulfide) are insoluble in water and consequently it is to be expected that some zinc will precipitate and be removed readily in most natural waters.

In zinc-mining areas, zinc has been found in waters in concentrations as high as 50 mg/1 and in effluents from metal-plating works and small-arms ammunition plants it may occur in significant concentrations. In most surface and ground waters, it is present only in trace amounts. There is some evidence that zinc ions are adsorbed strongly and permanently on silt, resulting in inactivation of the zinc.

Concentrations of zinc in excess of 5 mg/1 in raw water used for drinking water supplies cause an undesirable taste which persists through conventional treatment. Zinc can have an adverse effect on man and animals at high concentrations.

In soft water, concentrations of zinc ranging from 0.1 to 1.0 mg/1 have been reported to be lethal to fish. Zinc is thought to exert its toxic action by forming insoluble compounds with the mucous that covers the gills, by damage to the gill epithelium, or possibly by acting as an internal poison. The sensitivity of fish to zinc varies with species, age and condition, as well as with the physical and chemical characteristics of the water. Some acclimatization to the presence of zinc is possible. It has also been observed that the effects of zinc poisoning may not become apparent immediately, so that fish removed from zinc-contaminated to zinc-free water (after 4-6 hours of exposure to zinc) may die 48 hours later. The presence of copper in water may increase the toxicity of zinc to aquatic organisms, but the presence of calcium or hardness may decrease the relative toxicity.

Observed values for the distribution of zinc in ocean waters vary widely. The major concern with zinc compounds in marine waters is not one of acute toxicity, but rather of the long-term sub-lethal effects of the metallic compounds and complexes. From an acute toxicity point of view, invertebrate marine animals seem to be the most sensitive organisms tested. The growth of the sea urchin, for example, has been retarded by as little as 30 ug/l of zinc.

Zinc sulfate has also been found to be lethal to many plants, and it could impair agricultural uses.

Fluorides

As the most reactive non-metal, fluorine is never found free in nature but as a constituent of fluorite or fluorspar, calcium fluoride, in sedimentary rocks and also of cryolite, sodium aluminum fluoride, in igneous rocks. Owing to their origin only in certain types of rocks and only in a few regions, fluorides in high concentrations are not a common constituent of natural surface waters, but they may occur in detrimental concentrations in ground waters.

Fluorides are used as insecticides, for disinfecting brewery apparatus, as a flux in the manufacture of steel, for preserving wood and mucilages, for the manufacture of glass and enamels, in chemical industries, for water treatment, and for other uses.

Fluorides in sufficient quantity are toxic to humans, with doses of 250 to 450 mg giving severe symptoms or causing death.

There are numerous articles describing the effects of fluoride-bearing waters on dental enamel of children; these studies lead to the generalization that water containing less than 0.9 to 1.0 mg/l of fluoride will seldom cause mottled enamel in children, and for adults, concentrations less than 3 or 4 mg/l are not likely to cause endemic cumulative fluorosis and skeletal effects. Abundant literature is also available describing the advantages of maintaining 0.8 to 1.5 mg/l of fluoride ion in drinking water to aid in the reduction of dental decay, especially among children.

Chronic fluoride poisoning of livestock has been observed in areas where water contained 10 to 15 mg/l fluoride. Concentrations of 30 - 50 mg/l of fluoride in the total ration of dairy cows is considered the upper safe limit. Fluoride from waters apparently does not accumulate in soft tissue to a significant degree and it is transferred to a very small extent into the milk and to a somewhat greater degree into eggs. Data for fresh water indicate that fluorides are toxic to fish at concentrations higher than 1.5 mg/l.

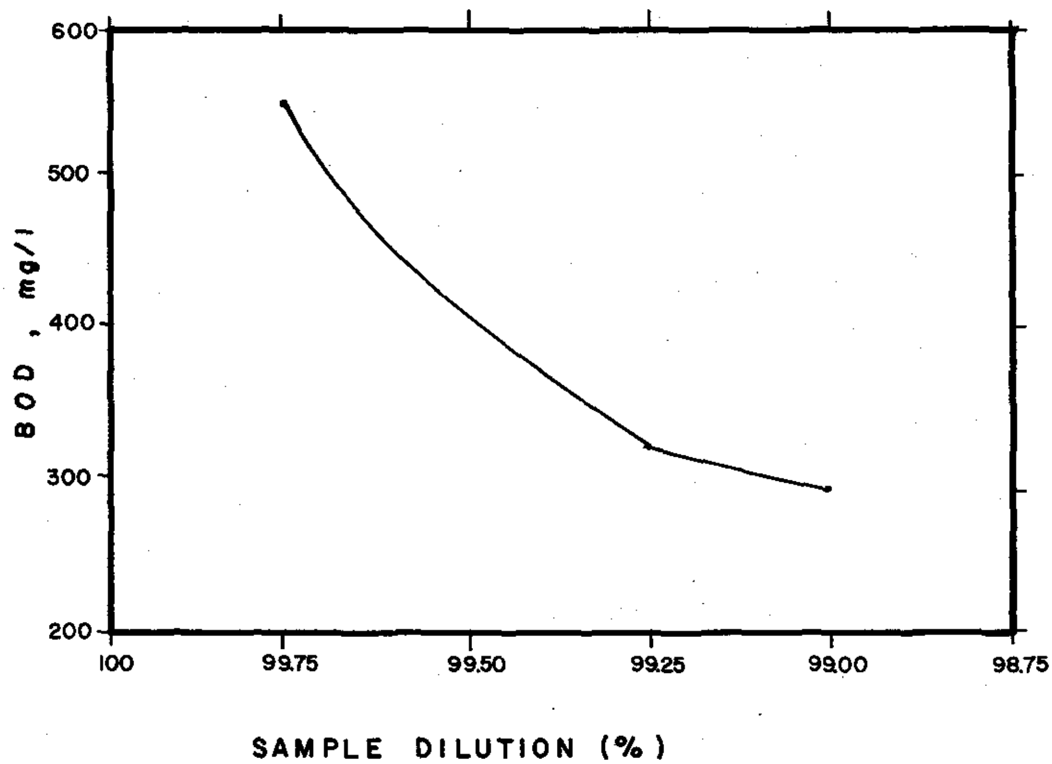


FIGURE 43. BOD -3 VARIATION WITH DILUTION

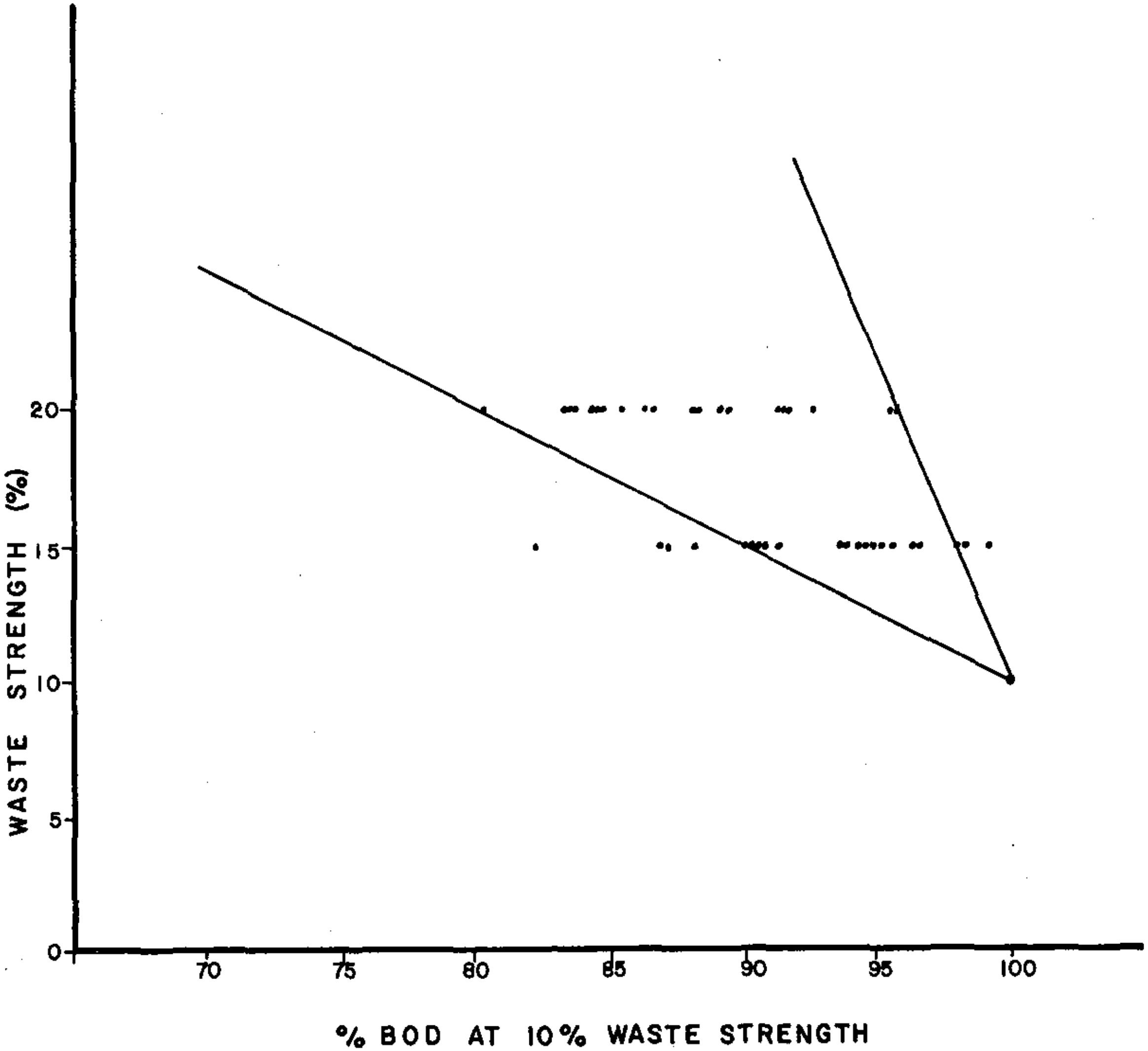


FIGURE 44. VARIATION OF BOD WITH
SAMPLE CONCENTRATION

TABLE 51

RETARDATION OF BOD TEST TIMBER PRODUCTS EFFLUENTS (LEACHATES)

Study Identification No.	Materials	Fish at Test	Concentration For TLm96 BOD	COD
1135	logs/w/bark	chinook, salmon	16.8	54.4
	logs/wo/bark	chinook, salmon	28.8	75.2
2176	bark-hardwood	chinook, salmon, fingerlings	69.3	537.6
	bark-softwood	chinook, salmon, fingerlings	63.00	483.0
2347	wood chips @40°C	guppies	92.4	336.0
	wood chips @32°C	guppies	108.8	400.0

NOTE: No dissolved oxygen data presented for the studies.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

This section identifies, documents, and verifies the full range of control and treatment technology which exists or is applicable to each operation identified in Section IV. In addition, it presents the control and treatment alternatives applicable to the model plants developed in Section V.

IMPOUNDMENTS AND ESTUARINE STORAGE AND TRANSPORTATION

The control of pollutants generated by log storage and transportation, other than log storage in ponds, can be accomplished primarily by operational modifications. Water pollution by log storage and transportation could be virtually eliminated by a transition of the industry to total land handling of logs; however, as indicated in Section VIII, the non water related environmental impact of such action would be severe.

The most important of the operational controls that have been investigated is the employment of easy let-down devices for placing logs into the water. The easy let-down devices and the practice of bundling logs either in the water or prior to placement in the water has been effective in reducing the eyesore of floating bark and the pollution problems associated with bark deposits on the bottom of waterways. In some instances, the number of logs in the water at any one time has been reduced considerably. This is practical for those locations where the impoundment is used only to feed the mill.

WET STORAGE

Presented below is a discussion of treatment and control technology applicable to the wet storage subcategory. The discussion is further broken down into mill ponds, log ponds, and wet decking operations. This breakdown of ponds into mill ponds and log ponds is useful in demonstrating the differences in quality and quantity of waste waters generated and the applicable treatment and control technology that are dependent on the type of activity occurring at the ponds, the location of the activity with regard to the location of the discharge and the throughput rates of the wood material and water.

MILL PONDS

The mill pond as it currently exists has evolved from the logging practices in the past. Waterways were used originally to transport logs from the forests to processing areas. As a result, most mill machinery is still water oriented, but the size of the water associated operations have diminished to the present mill pond. Most plants still dump logs into the mill pond in the same fashion as when loading logs from trucks and trains first became the practice. Most managers of mill pond operations allow a considerable amount of activity near the effluent structure and almost all still place the logs in the pond without prior bark removal. Some mills remove the ends of the logs while the log is still in the water, thus allowing sawdust to be contributed directly to the pond.

Existing Operational Control Measures

Several operational load measures may be taken to reduce pollution load of mill pond effluents. Logs can be barked prior to being placed in the pond. This practice substantially diminishes the amount of floating bark in the pond. Another control measure common to most mill pond operations is the use of baffles near the discharge effluent of the pond. The baffles are placed so as to protrude through the water surface. This prevents floating material from passing over the weir and out of the pond. In some cases, the baffles are placed far enough from the effluent weir that the bottom muds stirred up by the activity on the pond can settle and not be passed over the effluent weir. Another practice is the use of a submerged discharge, that is, the water to be discharged is drawn from below the surface of the pond. This prevents the carryover of floating material. Another operational control measure observed was the use of surface spray nozzles to contain the floating debris in a mill pond near the sawing operation. Surface sprays are particularly effective for control of sawdust generated by pond sawing operations. The screening of the water that entered the area near the mill operation to remove sawdust and bark from the water was also observed to be used as a control measure.

Potential Operational Control Measures

As previously mentioned, the sawing of logs while still in the water was observed in several locations. The elimination of this practice by sawing all logs on land would prevent the sawdust and bark generated from entering the pond water system. The removal of bark before placement in the water would reduce floating and settled bark as well as the leachates from the bark. When the logs are placed in the water without prior bark removal, smaller quantities of bark would be loosened from the logs if easy let-down devices were utilized. The quantity of water emanating from a mill pond can be markedly reduced if all storm runoff is diverted around the pond. This can be accomplished with an open diversion ditch in most cases, but in some cases, a larger closed conduit may be required. The amount of bottom materials stirred up during the log moving operations may be diminished markedly by using boats that have smaller engines than those currently in use. In this case, the decreased productivity of the operator would have to be a factor of consideration.

Potential Operational Control Measures

There are several potential control measures for reducing the effluent from ponds or increasing its quality. The primary source of influents to ponds may be drainage. However, since most log ponds also serve as mill ponds, they are normally kept full and overflow as a result of precipitation. One method of minimizing the amount of material washed from the log pond would be to enlarge the pond and allow the water levels to fluctuate. In that fashion the amount of water leaving the pond because of precipitation would only be that in excess of the amount evaporated. The pond would be at minimum depth at the end of the dry season and would overflow late in the rainy season. The water level in the model pond would fluctuate from 1 to 2 m (two to six ft) or more depending on the water balance for the area. This method would require the diversion of all drainage away from the pond, an action that in itself is a control measure.

Another operational control measure that would reduce the amount and possibly the concentration of pollutants in the pond effluent would be to prohibit all discharge or water streams to the pond. This would be the most effective of reducing discharge from the log pond, but it may not be the most practical approach when the entire mill complex is considered. The log pond can serve as an oxidation pond and it may have some assimilative capacity beyond that required for pollutants leached from the logs. Cooling water flows may need special consideration, yet the log pond can also serve as a cooling pond for heated water. Also, the addition of warm water during winter conditions can be beneficial in preventing freezing of wood and water.

The effluent from a mill or log pond may be screened for large solids removal. This will accomplish the removal of a portion of the suspended and floating solids, and primarily that portion that is aesthetically objectionable. Settling ponds may also be used for clarification of the pond effluent. An example of this technology for removal of settleable solids from both surface runoff and process water is reported in *Forest Industries*, November 1972. The ponds discussed in this reference had asphalt bottoms and sloped driveways leading into them. The ponds are periodically drained and the accumulated sediment trucked away.

TREATMENT AND CONTROL

The treatment and control technology currently available and that potentially available are essentially the same for log ponds and mill ponds. Unlike the mill pond, the amount of suspended solids in a typical log pond effluent is sufficiently low that the use of primary sedimentation is not necessary. If the water level in the log pond can be allowed to fluctuate, then the log pond itself can act as the basin. In application of the evaporation pond designed for the mill pond effluent to the log pond effluent, only spray evaporation must be added. This design concept was added to the treatment plant schemes for mill ponds.

For application of all of the designs for mill ponds to log ponds, the flow rate from the equalization basin to the treatment works was considered to be 3800 cu m per day (1.0 mgd). A laboratory study of the treatability of log pond waters by physical-chemical means by Blauton showed that sand filtration was relatively ineffective. The study showed that BOD removals of 7 to 49 percent and COD removals of 52 to 67 percent were possible using alum at an optimum coagulation pH of 5.0. The study further indicated that activated carbon could be used to reduce COD concentrations to less than 50 milligrams per liter even in the pond effluent by removing 272 to 485 milligrams COD per gram of carbon. The treatability of log pond waters using an activated sludge system with a detention time of from one to five days was studied by Hoffbahr. It was found that BOD, COD, and suspended solids removals of greater than 80 percent, 50 percent, and 60 percent respectively, could be obtained. The BOD, COD, and suspended solids of the influent waters were 52, 440, and 160 milligrams per liter, respectively.

The removal of lignins is important in the treatment of wood derived pollutants as shown by Wilson and Wong who studied the removal of lignins from solution using foam separation processes. It was found that foam fractionation is ineffective in removing lignins but ion flotation under the proper conditions yielded up to 91 percent removal. However, the total dissolved solids required for the separation to be possible was at such a high level as to render the process impractical.

The treatment of the wastes from mill ponds can be accomplished using both chemical-physical and biological processes. A thorough discussion of the various processes available can be found in waste water treatment texts. More specifically, Bailey investigated the applicability of aerated lagoons for treating pulp and paper mill wastes and found BOD reductions of up to 70 percent. In a study by Timpany, et al. 60 to 80 percent BOD removal efficiencies were illustrated for aerated lagoons with detention times of five days treating pulp and paper mill effluents. Other studies have substantiated the applicability of the technology for treating waste waters resulting from timber products processing waste stream.

Treatment Alternatives for Model Mill Pond

Six alternative treatment schemes were chosen for treatment of the effluent from the model mill pond. These systems are illustrated in Figure 45. A summary of the removal efficiencies of the alternatives is presented in Table 52. The treatment alternatives selected for the model mill pond are:

Alternative A:

No treatment

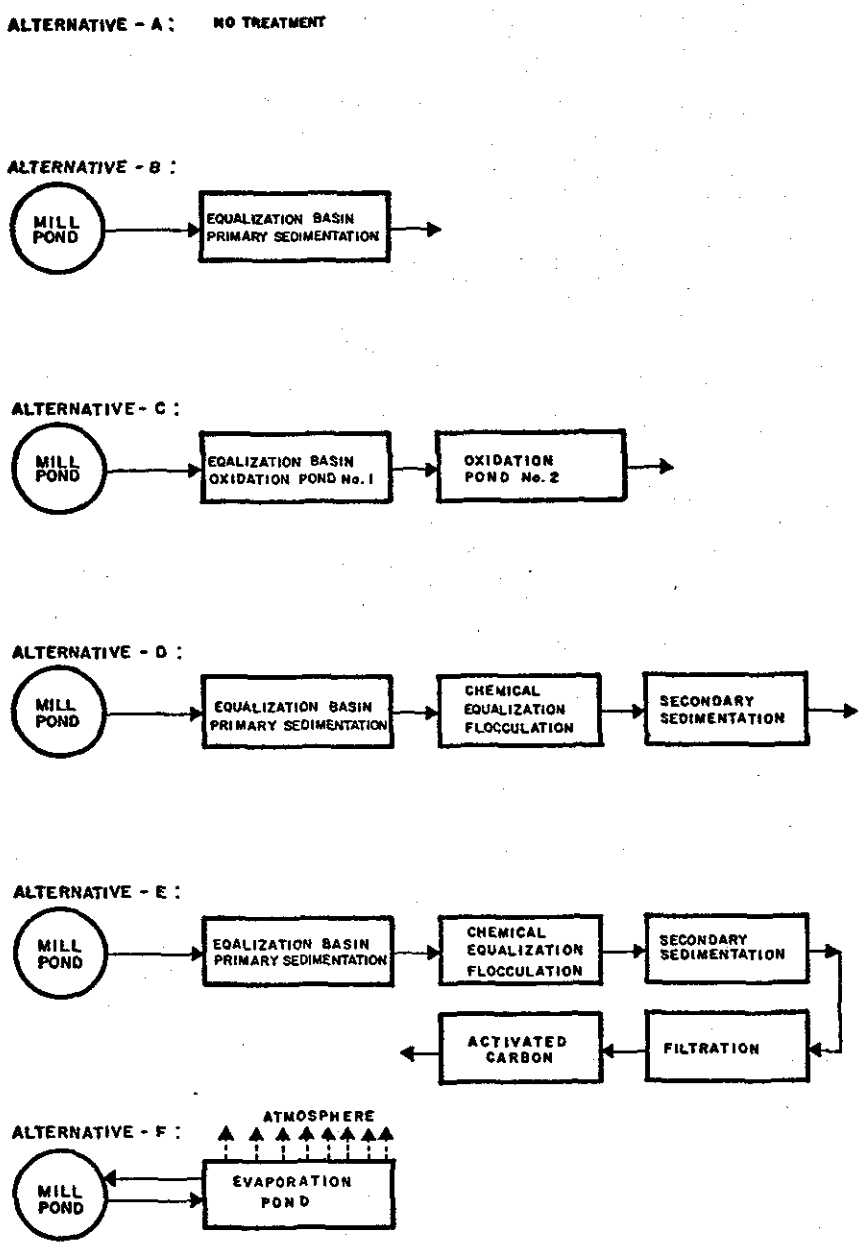


FIGURE 45 ALTERNATIVE TREATMENT SCHEMES FOR MILL PONDS

TABLE 52

EFFICIENCIES AND CONCENTRATION FOR THE VARIOUS TREATMENT ALTERNATIVES FOR MILL PONDS

Alternatives	Percent COD Reduction in the Unit	Percent Suspended Solids Reduction in the Unit	COD Influent Concentration (mg/l)	COD Effluent Concentration (mg/l)	Suspended Solids Influent Concentration (mg/l)	Suspended Solids Effluent Concentration (mg/l)
A	0	0	68	68	50	50
B1, C1, D1, E1	20	50	68	54	50	25
C2	60	20	54	22	25	20
D2, E2	60	90	54	22	25	2.5
E3	20	90	22	17.6	2.5	0.25
E4	75	0	17.6	4.4	0.25	0.25
F1	100	100	68	0	50	0

Alternative B:

Equalization basin and primary sedimentation

Alternative C:

C1 Equalization basin - oxidation pond No. 1
C2 Oxidation pond No. 2

Alternative D:

D1 Equalization basin - primary sedimentation
D2 Chemical coagulation - flocculation, secondary sedimentation

Alternative E:

E1 Equalization basin - primary sedimentation
E2 Chemical coagulation - flocculation, secondary sedimentation
E3 Filtration
E4 Activated carbon

Alternative F:

Evaporation pond

Alternative A - In alternative A, there is no treatment and, therefore, no reduction in the quantity of pollutants discharging from the mill pond. For those mill ponds that have high water volume throughput rate, diversion of that water around the mill pond will reduce the amount of pollutants discharged by the pond.

Alternative B - In alternative B, an equilization basin is coupled with a primary sedimentation unit. The mill pond that has had all extraneous water diverted from it will discharge only when precipitation occurs. The designs of mill ponds, and the predicted effluents are, therefore, a function of the size of the pond, the quantity of precipitation on the pond, and the rate of evaporation from the pond. The amount of precipitation and the evaporation rate were chosen based on geographical location. Because most mill ponds are located in the Northwest, and because the Seattle, WA, area has one of the highest rainfall rates and one of the lowest evaporation rates in the Northwest, the precipitation-evaporation data in the Seattle, WA, area were used. A one hectare (2.5 acre) pond was assumed. In this area, about 75 percent of the total annual precipitation occurs in the winter months. It was, therefore, assumed that treatment of the effluent would be necessary only during the winter months, and that the evaporation rate would exceed the precipitation rate and no discharge flow would occur during the summer months. An equilization basin must be provided to accomodate the high flows during rainy weather with flows during periods of no precipitation. A treatment plant could, therefore, operate with a nearly constant flow rate throughout the winter months. From the rainfall data, it was possible to calculate that the treatment plant would have to operate at a rate of 3 lps (50 gpm) and the equalization basin would have to have a volume of about 4000 cu m (1 million gal).

The effluent characteristics of the typical mill pond indicate that a sedimentation system might be a beneficial treatment process. In addition, it would be less costly to allow the equalization basin to also serve as a sedimentation chamber. This was considered and the design of the equalization basin modified accordingly.

The design for Alternative B then would be as shown in Figure 46. Design assumptions include the following:

1. The basin will be cleaned annually (in the dry season).

2. Cleaning to be performed with a drag line or a front end loader.

3. Water level will fluctuate between 0.9 m (3 ft) and 2.5 (8 ft) depth.

4. Sludge production is estimated at 200 cu m per year. Disposal would be by land spreading.

5. Basin walls = packed earth

6. Basin size at inside top of berm = 59.4 m

7. Effluent weir variable (by hand) from 0.9 m (3 ft) depth to 2.5 m (8 ft) depth.

8. Provide wet well for pump.

The predicted treatment efficiency for Alternative B1 is 20 percent COD removal and 50 percent suspended solids removal. These predictions are based on the characteristics of the effluent water, the laboratory studies reported previously, and the expected performance of this type of installation.

<u>Alternative C</u> - This alternative involves two steps. Alternative C1 consists of an equalization basin functioning as an anaerobic-aerobic oxidation pond with a variable influent and a constant effluent. The design of C1 is the same as the design of Alternative B.

Alternative C2 consists of an oxidation pond which receives the effluent from the equalization basin. The construction of the second oxidation pond is the same as the first with the exception that the berm is two m (seven ft) high and the basin size at the raised top of the berm is 53 m (175 ft) instead of the 59 m (195 ft) of the first basin. The effluent weir is arranged at an elevation that allows a maximum of one meter (five ft) of water to be maintained in the pond at all times.

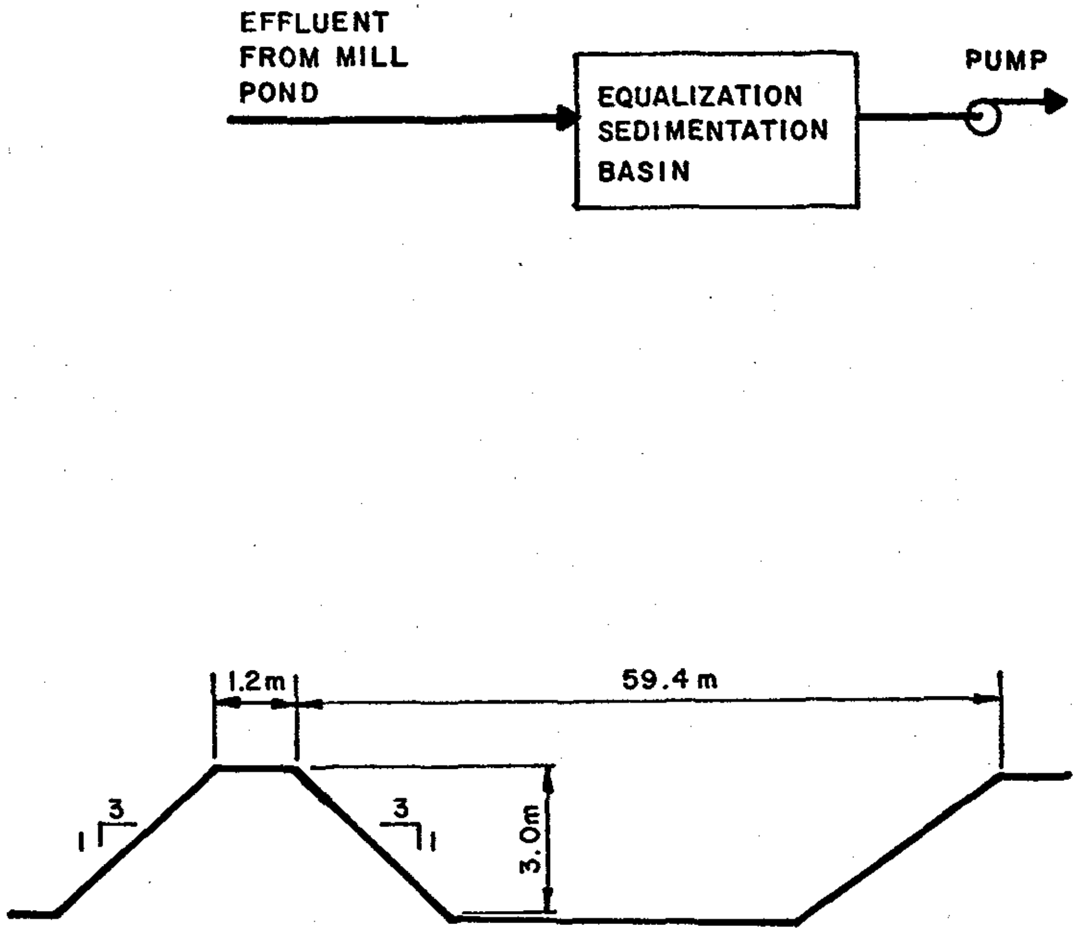


FIGURE 46 ALTERNATIVE B FOR MILL PONDS

The predicted treatment efficiency of Alternative C2 is 60 percent COD removal and 20 percent suspended solids removal. The higher COD removal results from a more uniform flow and a uniform detention time. The lower suspended solids reduction is based on the fact that most of the settleable solids will be removed in the first basin.

Alternative D - Alternative D consists of the addition of chemical treatment to the sedimentation equalization basin described for Alternative B and C1. Alternative D1 consists of the equalization basin. Alternative D2 consists of chemical coagulation, flocculation, and sedimentation.

Consideration was given in this alternative to chemical addition and mixing. A baffled flocculator was provided as well as a sedimentation tank. Sludge disposal was provided by using a settling pond with supernatant returned to the equalization basin. The sludge is assumed to be landfilled. The sludge pond is designed to accomodate both the sludge from chemical coagulation-flocculation-secondary sedimentation and filter backwash water.

The predicted COD and suspended solids removals for Alternative D2 are 60 percent and 90 percent, respectively. These removal efficiencies are normally expected for these units.

Alternative D2 is schematically shown in Figure 47. The following design criteria were employed:

1. Mixing and Chemical Addition

   a. Design flow = 30 lps.

   b. Mixing chamber = 0.5 m x 0.5 m x 0.5 m, made of steel or reinforced concrete.

   c. Mixer = 1.0 horsepower motor with appropriate blade.

   d. Flocculant feed pump = 10 to 40 l per hour.

   e. Coagulant feeding equipment = dry feeder for up to 90 kilograms per day of $Al_2(SO_4)_3$.

   f. Flocculant mixing equipment - 1 - 570 liter tank and a one and one-half horsepower mixer.

2. Flocculator

   a. The flocculator is a baffled channel.

   b. Construction = reinforced concrete.

   c. Around the end baffles in a folded channel.

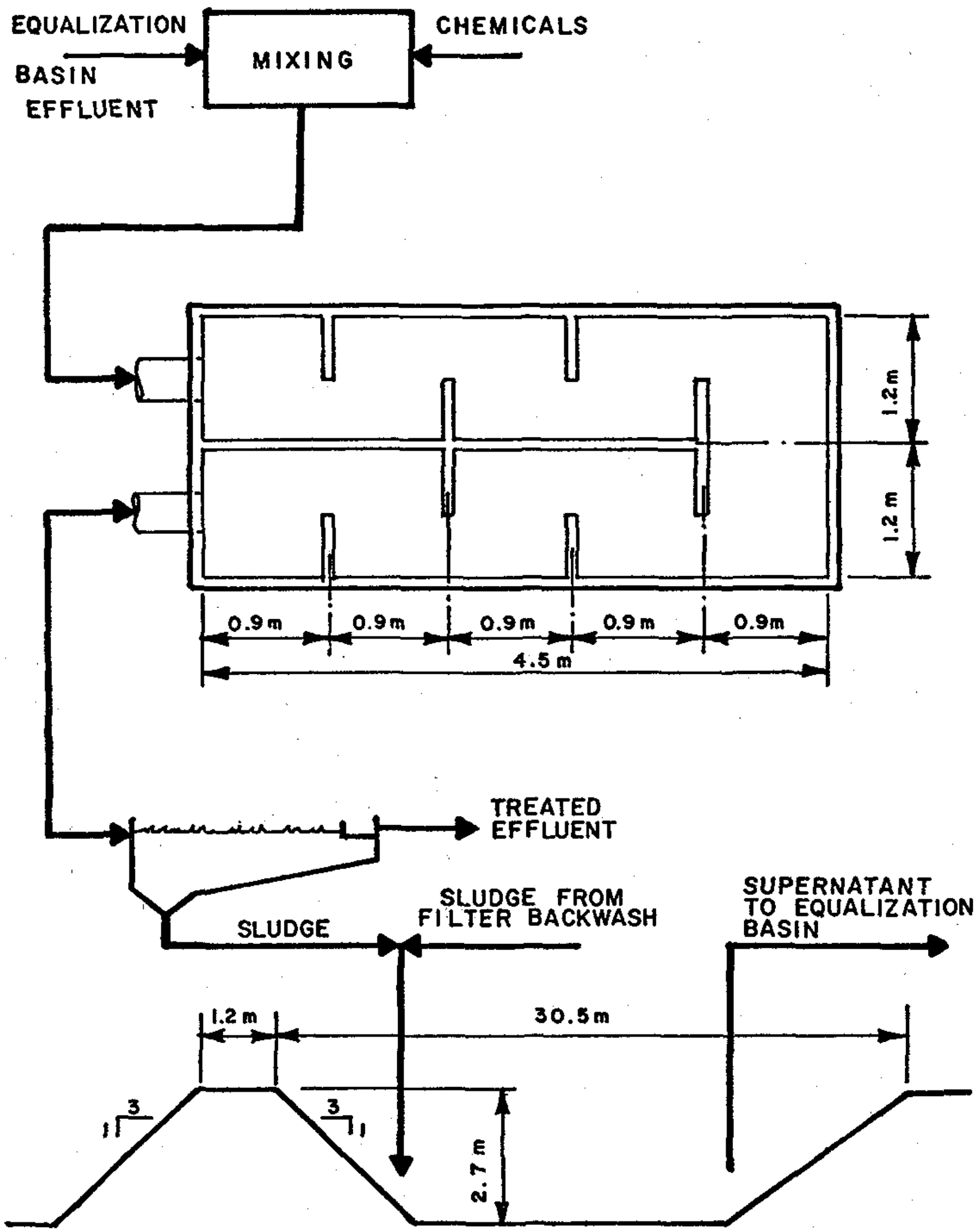


FIGURE 47 ALTERNATIVE D2 FOR MILL PONDS

d. Channel depth = 1.2 m.

3. Sedimentation Chamber

   a. Mechanically cleaned.

   b. Continuous sludge withdrawal.

   c. Surface skimming not necessary.

   d. Provide influent and effluent baffles.

   e. Longitudinal flow, rectangular tank.

   f. Depth = 3.7 m width = 2.4 m, and length = 4.3 m.

   g. Reinforced concrete construction.

5. Sludge Disposal

   a. Sludge from chemical coagulation-sedimentation and filter backwash water.

   b. Estimated settled volume = 490 cu m per year.

   c. Settling pond size 30.5 m x 30.5 m.

   d. Overflow weir @ 2 m depth.

   e. Annual cleaning.

   f. Sludge disposal to sanitary landfill.

   g. Pump to return supernatant to equalization basin.

Alternative E - In Alternative E, the unit operations of filtration and physical adsorption by activated carbon are added to Alternative D.
Alternative E is considered to consist of three steps:
Alternative E1, an equalization basin as designed for Alternatives B, C1, and D1;
Alternative E2, chemical treatment as designed for Alternative C2;
Alternative E3, single media pressure sand filtration; and
Alternative E4, activated carbon treatment.

Following the removal of a large portion of the suspended solids in the waste water by chemical treatment, the treated waste water still contains some solids from floc carryover. This floc will tend to plug the activated carbon system and reduce its efficiency for absorption of organics. Most of the floc can be removed by pressure filtration.

The activated carbon system is intended to remove soluble organics by physical adsorption. The system is designed as an upflow suspended bed of granular activated carbon. The spent activated carbon should be wasted or recharged off-site. Recharging on-site, for such a small quantity, would be cost prohibitive.

The predicted COD and suspended solids removals in the pressure filtration unit are 20 percent and 90 percent, respectively. In the activated carbon unit, the predicted COD removal efficiency is 75 percent, leaving a COD in the final effluent of less than 5 gm/l.

A schematic of Alternative E is shown in Figure 48. The following design criteria are involved:

1. Pressure Filtration

   a. Pressure sand filter (single media).

   b. Tank = 1.8 m diameter, 1.8 m height, with legs and manhole.

   c. Underdrain = graded gravel.

   d. Media = 80 cm of silica sand, effective diam = 0.5 mm, uniformity coefficient = 1.5.

   e. Two parallel units.

   f. Provide feed pump for 3 lps @ TDH = 15.2 m.

   g. Provide backwash pump for 25 lps @ TDH = 7.6 m.

   h. Backwash with dirty water from equalization basin, provide for initial filtration to equalization basin until effluent is clear.

   i. Backwash water treatment provided elsewhere.

2. Activated Carbon

   a. Upflow contactors.

   b. Three units, two operated in parallel while third is recharged.

   c. Must recharge one unit every two days.

   d. Provide underdrain system.

   e. Pumping for filtration will also serve for activated carbon.

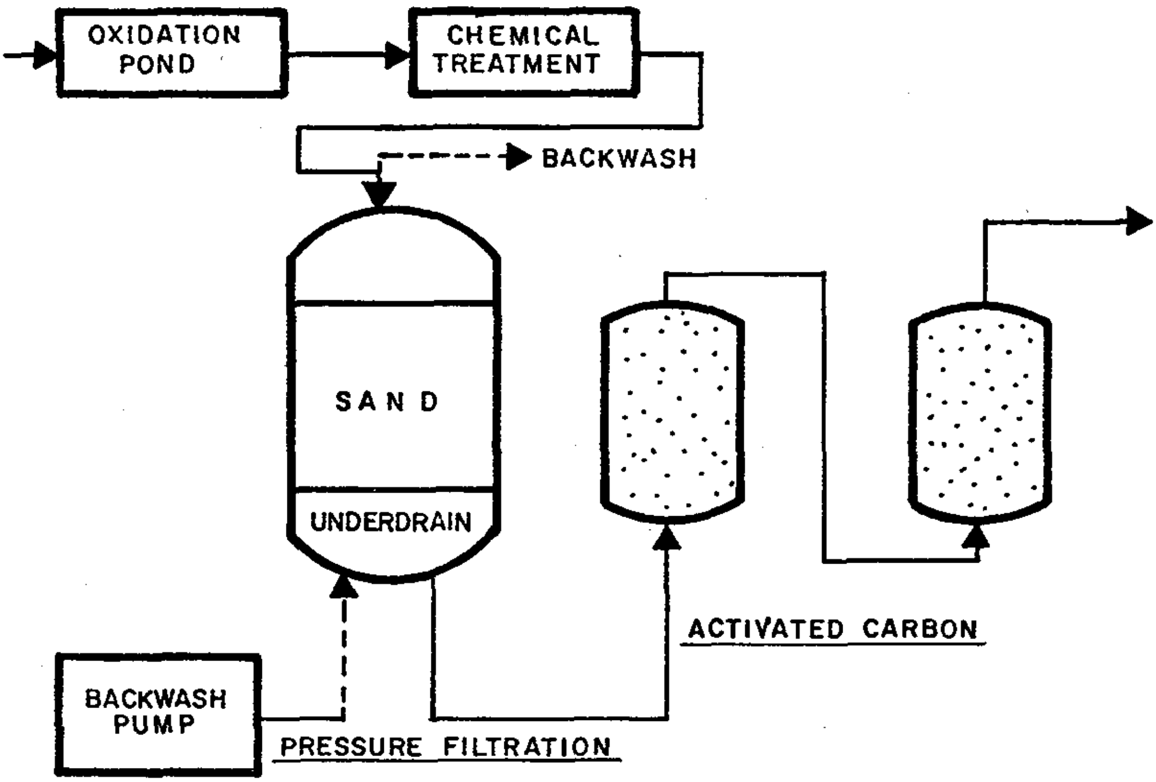


FIGURE 48 ALTERNATIVE E FOR MILL PONDS

f. Columns = 0.9 m diameter x 4.0 m height with removal tops.

g. Columns = steel tanks.

h. Provide for 102 kg of activated carbon per day.

i. Provide for recharge off site, or discard the spent carbon. If discard is used, the spent carbon will be incorporated in the sludge treatment system for coagulation and for filter backwash.

j. Provide for equipment to empty and fill columns.

k. Equipment will be housed in filter building.

Alternative F - Alternative F consists of an evaporation pond for the containment of the total discharge from the mill pond. The design of the evaporation pond takes into account the geographical variation of evaporation and precipitation rates. It provides for spray evaporators to operate continuously for five months of the year. The pond is designed to contain all precipitation falling on itself as well as that falling on the mill pond. The efficiency of the unit for removal of pollutants is 100 percent.

A schematic of Alternative F is presented in Figure 49. The following design criteria are employed:

1. Spray evaporation necessary (Seattle, Washington).

2. Pond size = 3 ha.

3. Pond shape = canal 38 m wide and 850 m long.

4. Sixteen floating pumps @ 75 hp each.

5. Pond depth = 3 m of water.

6. Place pond perpendicular to prevailing wind.

LOG PONDS

Log ponds differ from mill ponds in several ways including the fact that they are constructed at a key location for the specific purpose of storing logs. Most log ponds have processing mills on their banks and in many cases the mill discharges its waste water to the log pond. The discussion in this section will only be concerned with log handling operations on the pond and not with treatment and control measures relevant to extraneous streams entering the log pond.

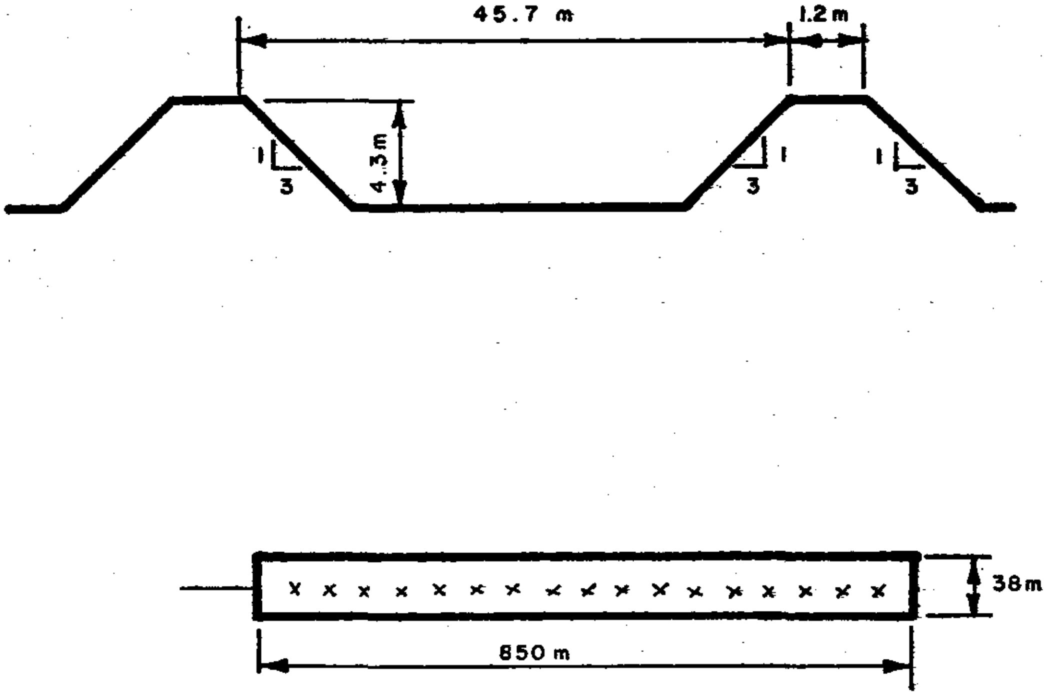


FIGURE 49 ALTERNATIVE F FOR MILL PONDS

Existing Operational Control Measures

The only existing operational control measure observed in this study is the bundling of logs prior to placement in the log pond. This practice decreased the bark loss during the log dumping operation and allowed more logs to be stored on the same pond.

Treatment and Control Technology

The treatment alternatives selected for the model log pond are illustrated in Figure 50. Table 53 presents a summary of the efficiencies of the alternatives. The selected alternatives are:

Alternative A:

No treatment

Alternative B:

B1 Equalization basin, oxidation pond No. 1
B2 Oxidation pond No. 2

Alternative C:

C1 Equalization basin
C2 Chemical coagulation - flocculation, sedimentation

Alternative D:

D1 Equalization basin
D2 Chemical coagulation - flocculation, sedimentation
D3 Filtration
D4 Activated carbon

Alternative E:

Use of the log pond as an evaporation pond.

Alternative A - In Alternative A, there is no treatment and no reduction of the pollutant load. Some of the inplant measures recommended previously should reduce the load from the log pond. All extraneous flows should be diverted around the log pond and, if possible, maximum water level fluctuation should be allowed.

Alternative B - In Alternative B an equalization-oxidation pond is coupled with a second oxidation pond (Alternative B2). The design of Alternative B1 for the pond was accomplished in the same fashion as Alternative C for mill ponds. The required storage in the equalization basin was found to be 53,000 cu m (14 million gal) and the treatment plant flow rate was in excess of 30 lps (500 gpm); therefore, a design flow of 3,800 cu m per day (one million gal per day) was used.

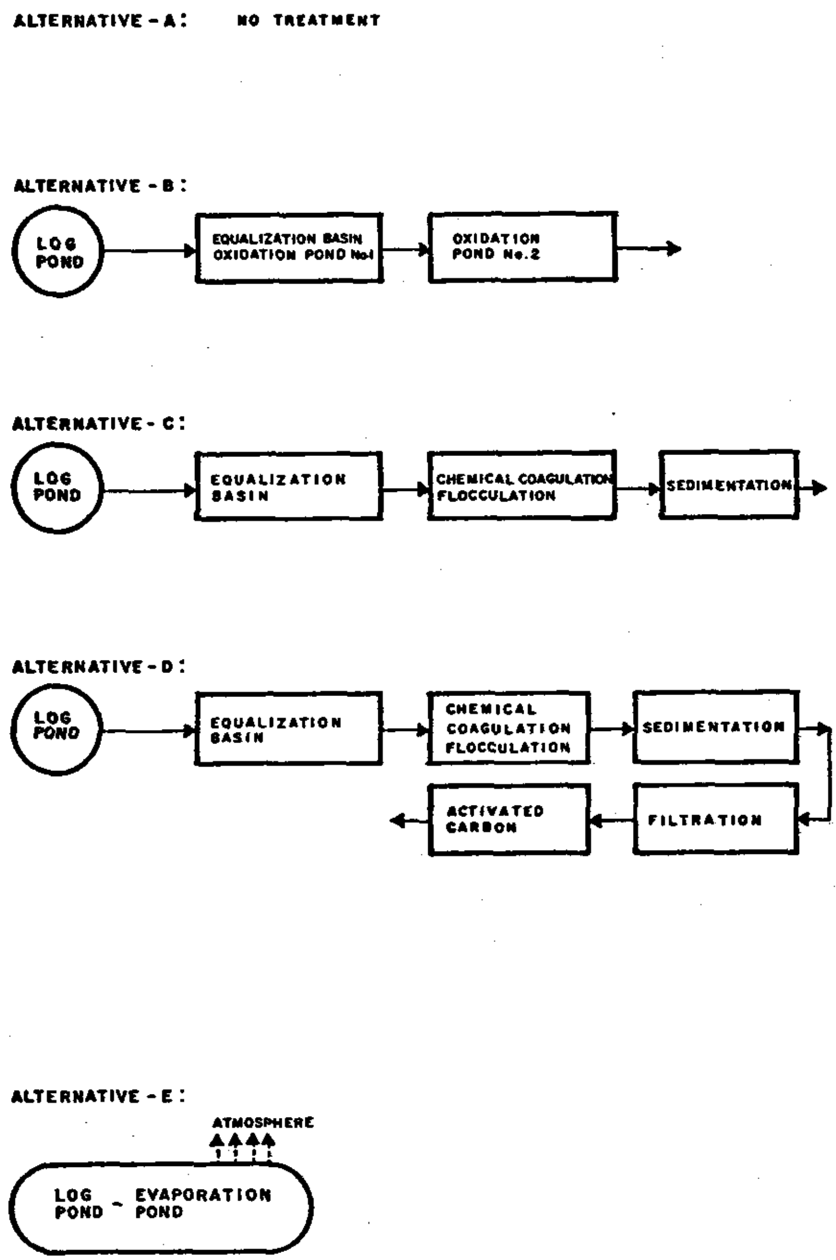


FIGURE 50 ALTERNATIVE TREATMENT SCHEMES FOR LOG PONDS

TABLE 53

EFFICIENCIES AND CONCENTRATIONS FOR THE VARIOUS TREATMENT ALTERNATIVES FOR LOG PONDS

Alternatives	Percent COD Reduction in the Unit	Percent Suspended Solids Reduction in the Unit	COD Influent Concentration (mg/l)	COD Effluent Concentration (mg/l)	Suspended Solids Influent Concentration (mg/l)	Suspended Solids Effluent Concentration (mg/l)
A	0	0	52	52	21	21
B1,C1,D1,E1	20	20	52	42	21	17
B2	60	50	42	17	17	8.5
C2, D2	60	60	42	17	17	1.7
D3	20	90	17	14	1.7	0.2
D4	75	0	14	3.5	0.2	0.2
E1	100	100	52	0	21	0

The waste water from a log pond is sufficiently low in suspended and settleable solids that a primary sedimentation chamber is not considered necessary. For this reason, Alternative B is a combination equalization basin and oxidation pond.

Just as in Alternative C for mill ponds, this design provides for a second oxidation pond, in series. In this case, the size of the second pond is the same as the first. The only difference is that the flow through the second pond is controlled by gravity rather than by a pump.

Alternative B1 provides a removal efficiency of 20 percent for both COD and suspended solids. Alternative B2 provides removal efficiencies of 60 percent and 50 percent for COD and suspended solids, respectively.

Alternative B is illustrated in Figure 51. The design criteria for each pond are as follows:

1. Effluent from the basin to be pumped at the rate of 3,800 cu m per day.

2. Water level will fluctuate between 0 and 1.5 m depth.

3. Provide wet well for pump.

4. Basin size at inside top of berm = 213.4 m

<u>Alternative C</u> - Alternative C consists of an equalization pond (Alternative C1) followed by chemical treatment (Alternative C2). The design and efficiencies of Alternative C1 are the same as for Alternative B1. The design of Alternative C2 is similar to the design of Alternative D2 for mill ponds. However, instead of the "around the end" baffle system in the flocculator used for mill ponds, Alternative C2 employs an "over and under" system. The reason for this difference is that more reliability is provided by the parallel sedimentation tanks of this design.

Alternative C1 provides a removal efficiency of 20 percent for both COD and suspended solids. Alternative C2 provides removal efficiencies of 60 percent and 90 percent for COD and suspended solids, respectively.

Alternative C is illustrated in Figure 52. The following design criteria are employed:

1. Mixing and chemical addition

    a. Design flow = 44 lps (694 gpm or 3,800 cu m per day (1 mgd).

    b. Mixing chamber = 1.8 m x 1.8 x 2.4 m deep, reinforced concrete.

    c. Mixer = 5.0 horsepower motor with appropriate blade

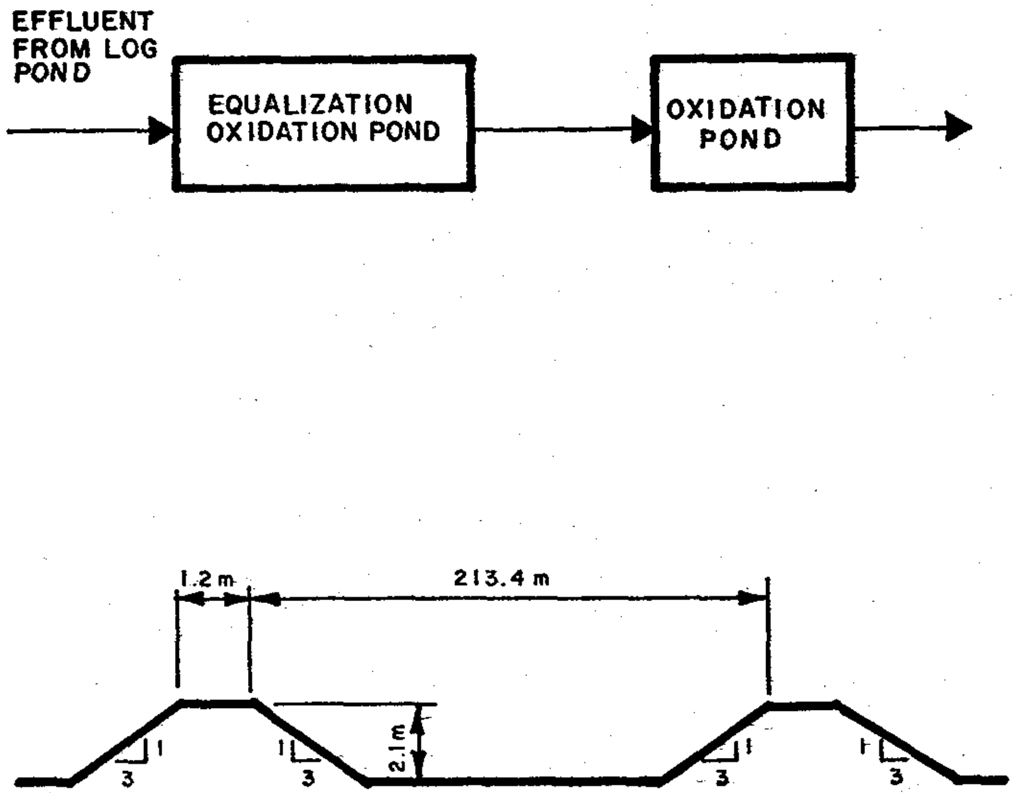


FIGURE 51 ALTERNATIVE B FOR LOG PONDS

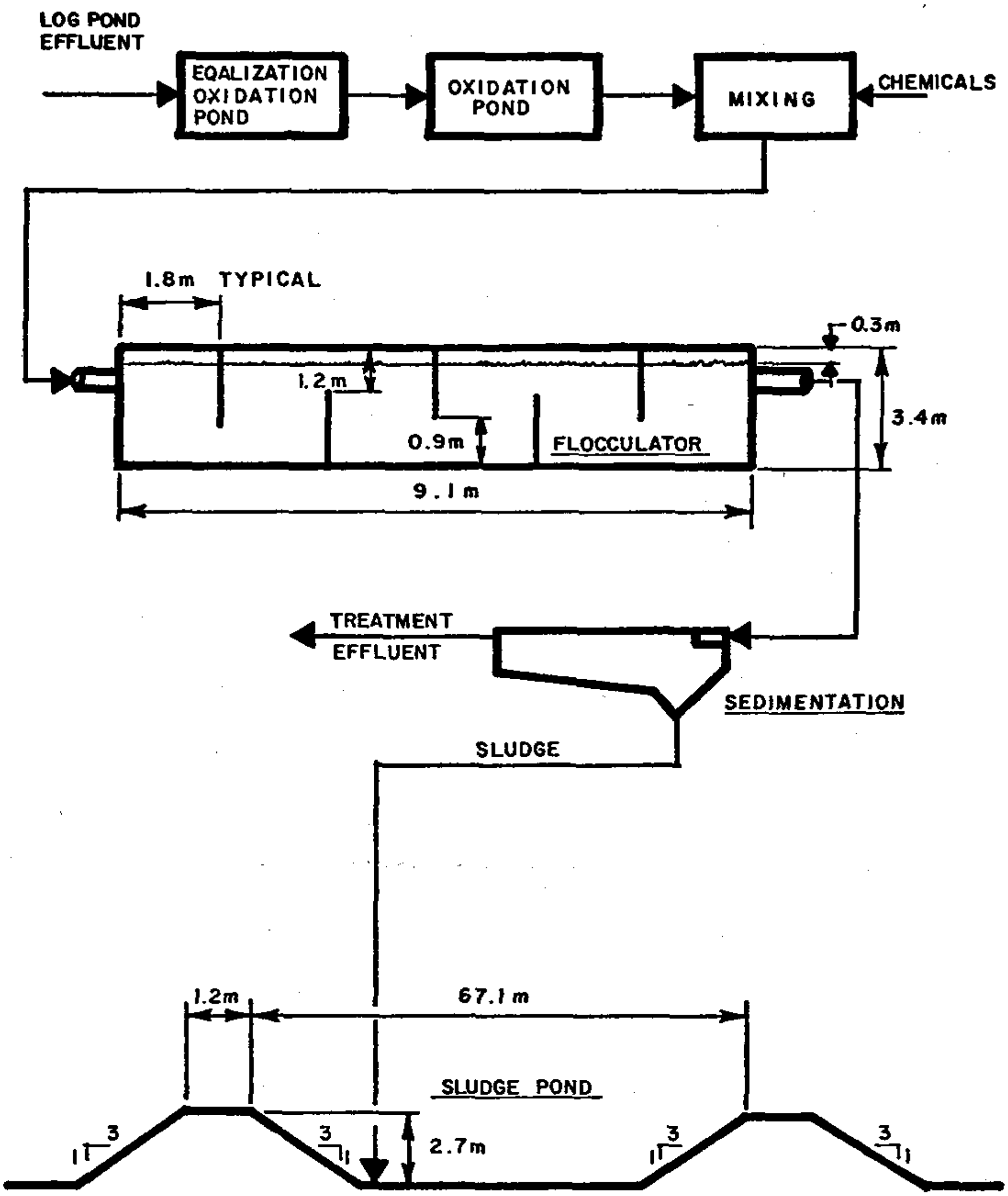


FIGURE 52 ALTERNATIVE C FOR LOG PONDS

d. Flocculator feed pump = 2 to 63 lps (30 to 100 gal per hour).

e. Coagulant feed equipment = dry feeder for up to 1,300 kilograms per day (2,800 pounds per day) of alum.

f. Flocculant mixing equipment = 1,900 l (500 gal) mix tank and two hp motor with mixer.

2. Flocculator

a. Over and under baffled channel.

b. Construction = reinforced concrete.

3. Sedimentation Chamber - Same as for mill ponds except:

a. Two parallel units with one common wall.

b. Size, depth = 3.7 m (12 ft), width = 3.7 m (12 ft), length = 15.2 m (50 ft).

4. House for feed equipment and chemical storage.

a. A metal building.

b. Size = 12.2 m (40 ft) x 12.2 m (40 ft).

c. One double door, one single door, two windows, lighting, exhaust fan, concrete pad, cold water taps, drain, no sanitary facilities.

5. Sludge disposal.

a. Same as mill ponds only larger.

b. Pond size 2.1 m (7 ft) deep, 67.1 m (220 ft) square.

c. Overflow weir @ 2 m (7 ft) depth

d. Annual cleaning.

e. Hauled to sanitary landfill.

<u>Alternative D</u> - Alternative D consists of applying filtration and activated carbon treatment to the effluent from Alternative C. Therefore, Alternative D1 consists of the equalization basin designed for Alternative B1 and C1, and Alternative D2 consists of the chemical treatment system designed for Alternative C2. Alternative D3 is a filtration unit utilizing gravity flow. Pressure filtration was not used in this case because of the large size of the units required. Alternative D4 is an activated carbon system similar to that designed for mill pond effluents,

except that in this case the rate of carbon consumption is sufficient to justify on-site regeneration. Therefore, three units are provided, two to operate in series while the third is recharged.

The removal efficiencies for Alternatives D1 and D2 are the same as for Alternatives C1 and C2, respectively. The removal efficiencies for Alternative D3 are 20 percent and 90 percent for COD and suspended solids, respectively. The removal efficiency of Alternative D4 is 75 percent for COD.

Alternative D is illustrated in Figure 53. The following design criteria are employed:

1. Filtration unit

   a. Gravity sand.

   b. Two boxes of reinforced concrete each 3.0 m (10 ft) wide, 10.7 m (35 ft) long, and 4.6 m (15 ft) deep.

   c. 76 cu m of silica sand - effective diameter = 0.5 mm and uniformity coefficient = 1.5.

   d. Underdrain = graded gravel.

   e. Feed pumps are assumed to be unnecessary.

   f. Backwash pump 331 lps (5,250 gpm @ TDH=7.6 m (25 ft).

   g. Backwash water treated in sludge settling pond with other sludge.

   h. Housing = increase coagulation and chemical storage building to 18.3 m (60 ft) x 18.3 m (60 ft).

2. Activated Carbon

   a. Same as mill ponds except for size and necessity for pumping.

   b. Three tanks 3.0 m (10 ft) diameter, 4.0 m (13 ft) tall.

   c. Provide for 1,400 kg (3,000 lb) of activated carbon per day.

   d. This dose rate is within the regeneration range. Therefore, provide a carbon regeneration system.

   e. House regeneration equipment - make existing building 18.3 m (60 ft) x 24.4 m (80 ft).

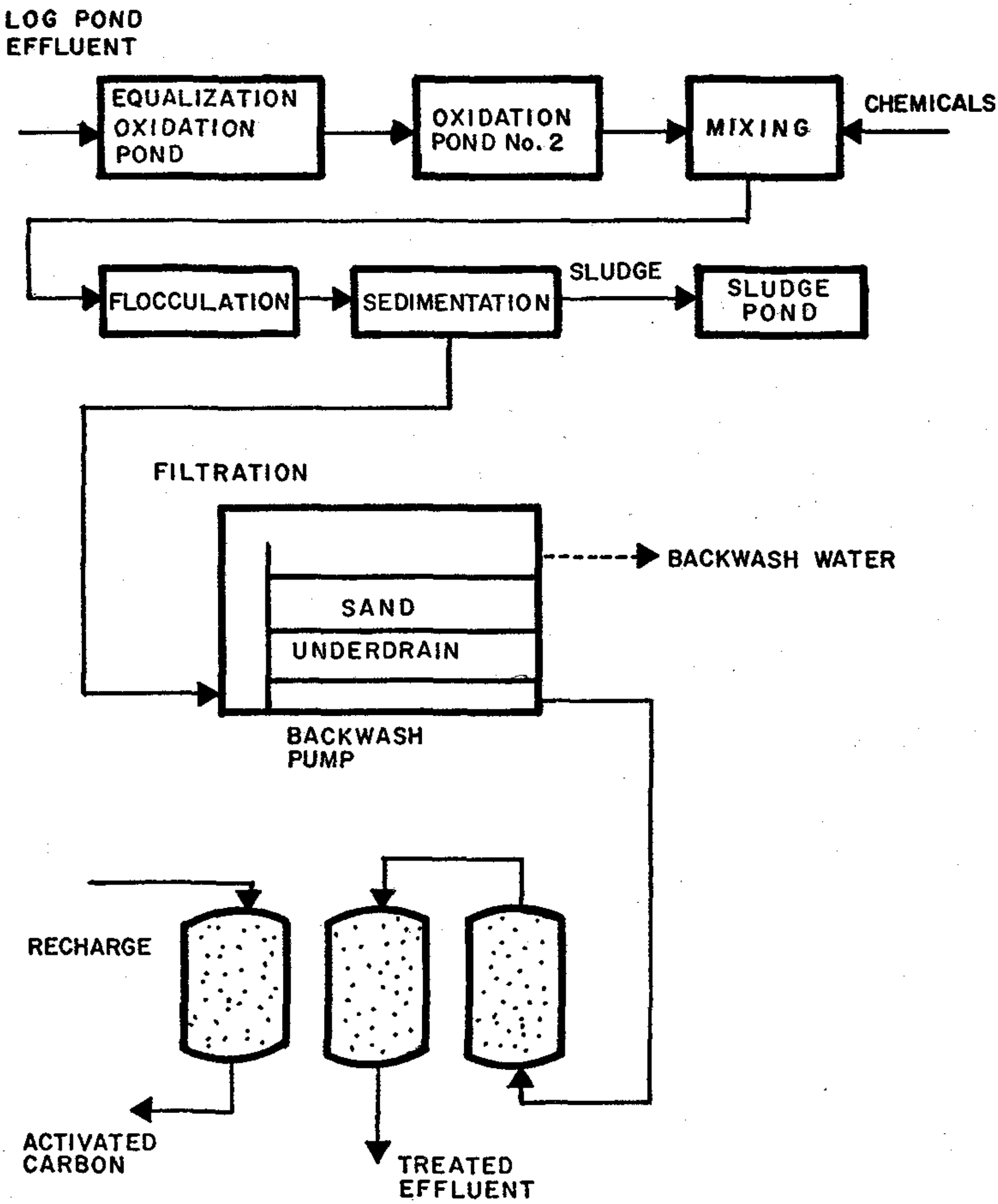


FIGURE 53 ALTERNATIVE D FOR LOG PONDS

Alternative E - Alternative E consists of the installation of spray evaporation units directly on the log pond. Alternative E requires 42 spray units for the model pond. The units should be engineered to allow operation of individual units. The spray falling on the logs would aid in preserving the logs and the logs may increase the evaporation rate. The pond would have to be sufficiently deep to provide a two meter (seven ft) water level fluctuation for winter storage. The spray evaporation would be operated 24 hours per day during the five months of operation. With proper design and operation the pond will have no discharge and the treatment efficiency is 100 percent.

WET DECKING

An alternative to the storage of unprocessed wood in ponds is storage on land. To preserve land decked logs, the logs are often sprinkled with water. The water must be relatively free of solids in order to pass through small diameter spray nozzles.

Existing Inplant Control Measures

The most common type of water spray nozzle in use in wet deck spray systems is the "rainbird". This nozzle delivers the water to the atmosphere from a 0.3 cm (1/8 in) diameter rotating nozzle. The water from this spray wets a 15 to 30 m (50 to 100 ft) diameter circle. An alternative spray system that delivers a mist. This mist wets a 3 to 6 m (10 to 20 ft) diameter circle and must be very close to the log surface because wind may blow the mist away from the logs. One such installation, observed on a warm dry day, resulted in no water discharge from the log deck. It was all evaporating or infiltrating into the ground at the site. While these nozzles have the advantage of producing little or no runoff, they have several disadvantages. There must be more nozzles used on the same size log deck and there can be virtually no suspended solids in the water or the nozzles will plug.

Another inplant control measure is the recycling of wet deck water. The water discharge from the wet deck is collected in a settling basin, sometimes as small as 9 m by 9 m (30 ft by 30 ft), which removes grit and readily settleable solids. The clarified water is pumped back to the wet deck spray nozzles. The fine mist producing spray nozzles usually cannot be used on a recycled wet deck because of inadequate solids removal in the settling pond. Water must be added to the system during dry periods because the evaporation rate for a wet deck is considerably higher than for quiescent waters. An overflow structure is usually provided on the pond.

Potential Inplant Control Measures

The most effective control measure available to the operator of a wet decking facility is the control of the volume of water sprayed on the wet deck area. This requires strategic placement of the spray nozzles and control of the periods when the spray system is operated.

The number of spray nozzles and, consequently, the flow of water to the wet deck could be reduced by making the deck higher and shorter. This may add significantly to the cost of decking, because it would have to be performed with a crane rather than the front-end loader that is commonly used. It would also add significantly to the danger associated with placing and removing logs from the deck.

The land deck could be covered and a high humidity environment maintained under the cover. Plastic drape covers have been used to protect roundwood stored for the pulp and paper industry, but wind readily tears the covering from the pile. For this reason, a firm frame for the cover material would probably be necessary.

Treatment and Control Technology

The treatability of the effluent from a wet deck was assumed to be the same as that of log pond waters since the chemical analyses obtained in this study showed that the effluent waters for wet decking operations are similar to those from mill and log ponds. Therefore, the treatment technology can be considered to be similar.

Six treatment alternatives were considered in wet decking effluents but two different flows for each scheme are presented. These flows correspond to those expected from a one ha (3 ac) and a 20 ha (50 ac) wet deck. These alternatives are shown diagramatically in Figure 54. Table 54 presents a summary of treatment efficiencies for the treatment alternatives. The treatment alternatives selected for the typical wet decking operations are:

Alternative A:

No treatment, cost of small recycle pond.

Alternative B:

Recycle-equalization-sedimentation pond

Alternative C:

C1 Recycle-equalization-oxidation pond #1.
C2 Oxidation pond #2.

Alternative D:

D1 Recycle-equalization-sedimentation pond.
D2 Chemical coagulation-flocculation.
D3 Secondary sedimentation.

Alternative E:

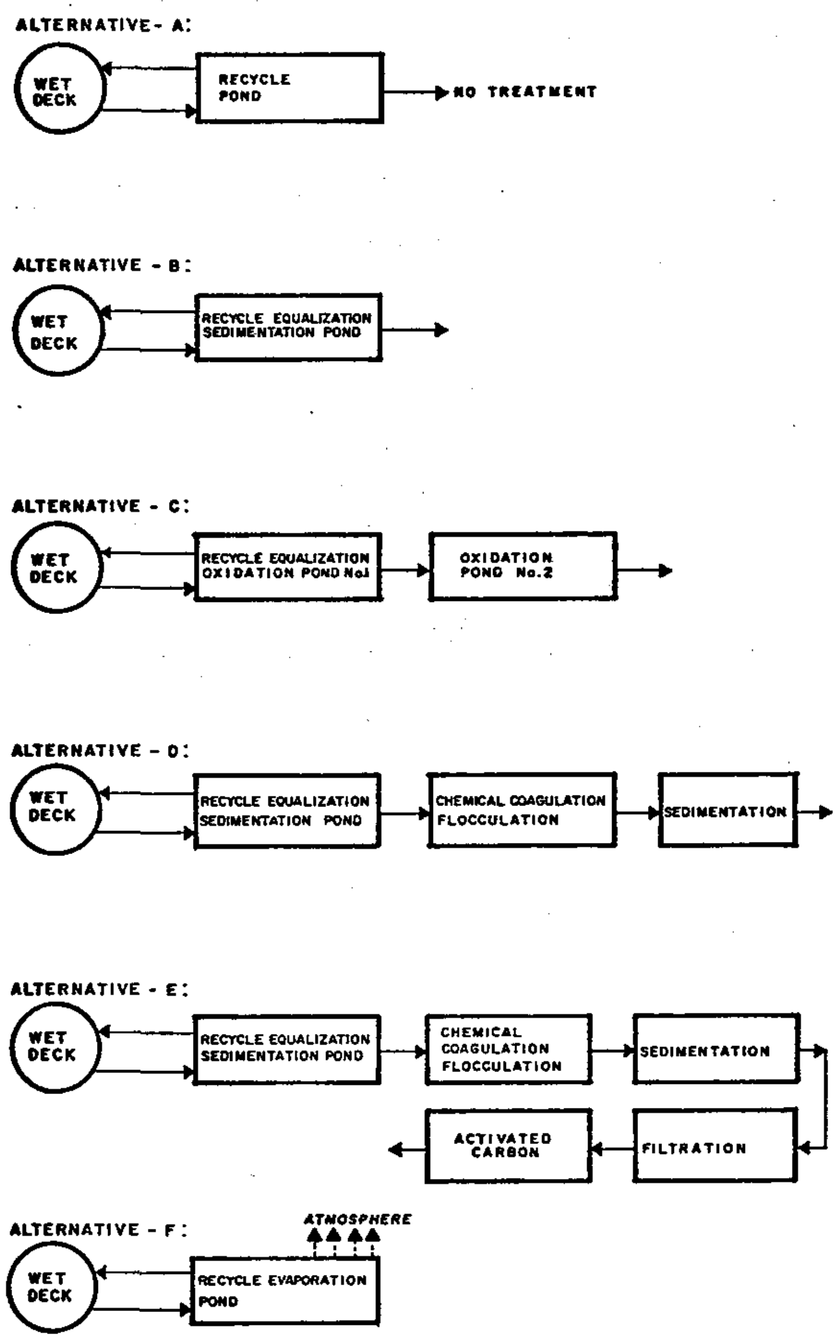


FIGURE 54 ALTERNATIVE TREATMENT SCHEMES FOR WET DECKING

TABLE 54

EFFICIENCIES AND CONCENTRATIONS FOR THE VARIOUS TREATMENT ALTERNATIVES FOR WET DECKING

Alternative	Percent COD Reduction in the Unit	Percent Suspended Solids Reduction in the Unit	COD Influent Concentration (mg/l)	COD Effluent Concentration (mg/l)	Suspended Solids Influent Concentration (mg/l)	Suspended Solids Effluent Concentration (mg/l)
A	0	0	155	155	100	100
B1,C1,D1,E1	20	50	155	124	100	50
C2	60	20	124	50	50	40
D2, E2	60	90	124	50	50	5
E3	20	90	50	40	5	0.5
E4	75	0	40	10	0.5	0.5
F1	100	100	155	0	100	0

E1 Recycle-equalization-sedimentation pond.
E2 Chemical coagulation-flocculation.
E3 Secondary sedimentation.
E4 Filtration.
E5 Activated carbon.

Alternative F:

Recycle-evaporation pond.

Alternative A - There is no treatment and no removal of pollutants for Alternative A.

Alternative B - Alternative B is the same design as Alternative B for mill ponds and Alternative B for log ponds. The removal of sludge from the log pond alternative must be considered. The removal efficiencies are the same.

Alternative C - Alternative C is the same as Alternative C in mill ponds and Alternative B for log ponds.

Alternative D - Alternative D is the same as Alternative D for mill ponds and Alternative C for log ponds.

Alternative E - Alternative E is the same as Alternative E for mill ponds and Alternative D for log ponds.

Alternative F - Alternative F is a recycle-evaporation pond. Evaporation ponds for wet decks of a size larger than one hectare (3 ac) are unrealistic as a treatment technique. For this reason, this alternative is the same as Alternative F for mill ponds. There is no method considered to be reasonable for achieving zero discharge or 100% treatment in wet decks larger than one hectare (3 ac).

DRY DECKING

Some of the operational control measures applicable to wet decking, such as the minimization of log inventories, and alteration of deck configuration, are also applicable to dry decks. However, since dry decked logs are only subject to natural precipitation,, and runoff results only after sufficient rain has fallen, the operational control measures are fewer and, to some extent, different.

No operational control measures are currently practiced for dry decking operations. In general, the decks are located on high, dry ground in order to facilitate log handling during wet weather. This has the added advantage of minimizing the amount of surface water passing through the deck. Other efforts to divert the flow of surface storm runoff from the log decks, such as channelization of the runoff, can substantially reduce the waste water stream generated by dry decks.

Another potential control measure is reduction of storage inventory to a minimum operating level.

A potential method for pollutant reduction is the utilization of greater depths in the decks. Greater rainfalls would be required to wet the taller decks and, consequently, to produce runoff.

Covering of decks with plastic sheets or other materials is a method of preventing polluted runoff; however, the problems associated with this measure include: 1) the covering tends to be blown away during winds, 2) log accessibility can be seriously impaired, and 3) the cost would tend to be excessive for decks of substantial size.

The end of line technology discussed for wet decks would appear to be somewhat applicable to dry decks; however, the absence of adequate flow information and comprehensive studies of effects of species diversities, as discussed in Section V, precludes the development of detailed designs for treatment alternatives for dry deck effluents.

STORAGE OF FRACTIONALIZED WOOD

Fractionalized wood, including such materials as bark, chips, planer shavings, and sawdust, are stored in piles as waste materials at sawmills, veneer mills, and other operations such as insulation board and particleboard production and by-product recovery.

As discussed in Section V, Water Use and Waste Characterization, the retention time of the wood based material in a pile is an important factor affecting waste water characterization and, therefore, applicable pollution control techniques. In general, rapid utilization of the piles, as practiced as a matter of course at particleboard plants, is a method of pollution reduction.

The use of fractionalized wood as boiler fuel can significantly reduce both a water pollution problem and a solid waste disposal problem. However, an increase in particulate emissions from the boiler can result. An air pollution problem is also associated with the use of Teepee burners and a widespread ban on the use of such burners for fractionalized wood destruction has led to extensive stockpiling of chip and particle piles.

Following a reduction of inventory to minimum levels practicable, additional steps can be taken to reduce water pollution from fractionalized wood piles. The practice of allowing yard storm runoff to flow into piles can be avoided by diverting storm water around or away from the piles. With such a diversion, the only water generated from the piles is that originating from rainfall directly on the piles or from their initial moisture content. Yard runoff can also be prevented from entering piles by an initially selection of storage sites on high, dry grounds.

Waste water generation by fractionalized wood piles could be virtually eliminated by either storing the materials inside the plant building, as is the case in some particleboard plant operations, covering them with a roof, or placing a waterproof material over them. Unfortunately, few plants that do not currently store these materials inside have the ability to do so, and, as in the case of dry decks, covering of outside piles is restricted by material accessibility and high cost. In the case of long term storage, however, as indicated by McKee and Daniel covering of piles with polyethylene may be practical and offers the advantages of reduction of decay and opportunities of longer storage.

It would appear that treatment technology similar to that discussed for wet decking operations would be applicable to waste waters generated by storage piles of fractionalized wood. However, although the chemical make up of the waste water is presented in Section V, available flow data is insufficient to allow design of treatment facilities.

LOG WASHING

Treatment and control technology as practiced in sawmills with respect to log washing effluents consist of no treatment; sedimentation and discharge; or sedimentation and recycle. Two mills report total recycle of settled effluent. One of these utilizes three rectangular steel basins in series, accomplishing grit removal primarily, with recycle being from the third basin. The other mill uses a dirt basin approximately 15 m (50 ft) in diameter by two m (six ft) deep to settle 25 l/sec (400 gpm) of log wash effluent. The effluent of the basin is recycled following fine screening. The system has been operated successfully for over one year. Both mills report that periodic removal of sludge is necessary. The inclusion of adequate sludge handling capabilities should allow maintenance of total recycle indefinitely.

The recommended system to provide 100 percent recycle consists of coarse screens with screen openings of about 0.64 cm (0.25 in) for removal of large bark and wood solids from the waste water followed by a rectangular settling basin which provides a surface overflow of 41,000 lpd/sq m (1000 gpd/sq ft) and a detention time of two hours. The effluent from this tank should pass through fine screens prior to recycle. Sludge from the settling basin should be pumped to a sludge pond for thickening. The sludge pond should be sized so as to require only periodic dredging and disposal of sludge. Figure 55 illustrates the recommended recycle system.

SAWMILLS

As discussed in Section V, exemplary sawmill operations currently do not discharge waste water other than from log storage ponds or storage piles of fractionalized wood (discussed separately in

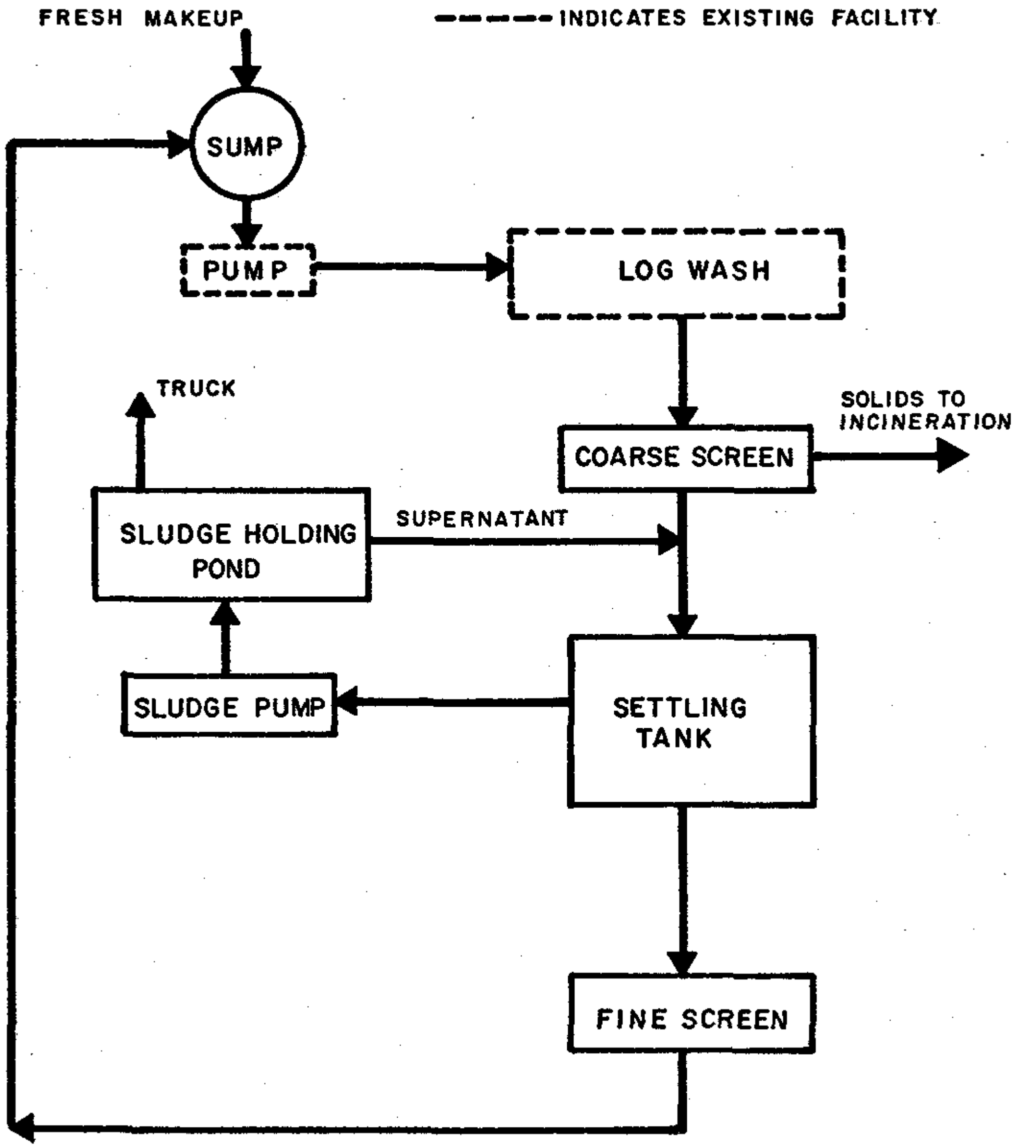


FIGURE 55 LOG WASH RECYCLE SYSTEM

this report), bark removal operations, boiler blowdown, and noncontact cooling water sources.

Frequently, the practice in a sawmill is to allow cooling water to flow from the mill site in open ditches. This results in contamination of the cooling water by sawdust, wood scraps, oil and grease, and other substances. It can be avoided by discharging the cooling water through closed conduits. This will be feasible except where receiving stream flow is too low to avoid a deterioration of water quality because of temperature rise. It is also a frequent practice to discharge cooling water to log ponds, especially during winter months to prevent the ponds from freezing. This practice results in the production of large volumes of polluted log pond water and should be avoided unless adequate treatment of the log pond effluent is provided.

Other control techniques which lead to the elimination of pollutant discharges from a sawmill consist of various housekeeping measures and management practices, many of which are current practice. Saw cooling water and chain lubricating water usage can be minimized to avoid the production of waste streams. This can be accomplished by the installation of special flow control systems or by reducing the flow to the minimum required volume. This will result in all saw cooling water being absorbed in the sawdust.

Mill cleanup should be practiced on a frequent basis both inside and outside the mill to avoid the buildup of bark and dust and subsequent leaching and precipitation runoff. All cleanup can be done without the use of water. Hog fuel piles should be covered where possible or ditches to divert stormwater should be constructed.

Where stains or anti-staining compounds are used, all excess materials should be recycled and all cleanup water should be used for makeup in subsequent batches. Dip vats should be covered to keep out precipitation and should be equipped with an apron to catch all drippage from dipped lumber. Any glue using operations in the mill should adopt treatment alternatives recommended in the fabricating operations section of this report.

In summary, the following practices are recommended and are considered to be current utilized practice at the model sawmill:

1. Cooling water should be discharged after use in cooling pumps, turbines or condensers by way of closed conduits rather than open ditches.

2. Waste materials such as bark and sawdust should be utilized wherever possible for fuel or otherwise and should not be allowed to accumulate.

3. All stains, preservatives and coating compounds applied to lumber should be totally contained. Where water is

required for cleanup of these systems, it should be reused as makeup for the next batch.

4. Cleanup in and around the sawmill should be done frequently to avoid buildup of bark and sawdust. All cleanup should be done without water.

5. Saw cooling water usage and chain belt lubricating water usage should be minimized.

FABRICATION

Fabrication with water soluble adhesives and associated cleanup operations results in the production of an intermittent, concentrated waste water. The volume of this waste water has been shown in previous sections to be related to the number of applicators and mixing vessels present at a particular plant. In general, the volumes observed have been of approximately two orders of magnitude. For most fabricating operations, the volume of glue wash water will be in a range from 95 lpd to 1,100 lpd (25 gal per day to 300 gal per day). However, for some larger glue users, most notably the laminated structural wood products industry, the volume of waste water produced may fall in a range from 4,000 lpd to 8,000 lpd (1,000 gal per day to 2,000 gal per day). For this reason, control and treatment recommendations and designs are based on two distinct volume ranges.

In-Plant Control Measures

In-plant control measures to reduce the volume of waste waters consist of various cleanup techniques. One of these techniques consists of scraping the mixing tanks and other surfaces to remove as much of the glue residue as possible. This technique in combination with high pressure hoses can reduce the total volume of wash waters appreciably. Steam or steam and water mixtures can also reduce water usage. Steam cannot be used on rubber rollers, but it is applicable to extruder and mixing tank cleanup. Also, at least one fabricating operation applies a heavy duty grease to the extruder surfaces to prevent the glue from contacting the metal surfaces. It is estimated that with the application of these techniques the volume of water required for cleaning applicators can be reduced from 800 l (200 gal) per cleanup to less than 400 l (100 gal) per cleanup.

End of Line Control Technology

Present control and treatment technology for glue wash water in the fabrication industry consists of containment in lagoons with periodic dredging of solids with disposal to landfill, landspread, or municipal sewers. Several treatment methods result in no discharge of glue wash water. This can be accomplished by screening of the larger glue solids and other residue followed by a variety of alternatives including:

1. Discharge to a shallow lagoon sized such that evaporation and infiltration will allow total containment. Spray evaporators may be required in some regions of high precipitation and limited land availability.

2. Discharge to a holding tank from which glue wash water can be trucked to landfill, landspread, or sprayed on hogged fuel to be burned.

3. Discharge to a holding tank from which the wash water can be reused as wash water in cleanup operations. Depending on the type of resin used at a particular plant, it may be possible to use a portion of the wash water as makeup water in glue mixing. A portion of wash water will possibly require bleedoff which can be handled by evaporation or incineration.

Evaporation ponds without spray evaporators are presently a common control technique for disposal of glue wash water. However, because of the high percentage of dissolved solids in the resin mix, it is quite likely that zero discharge conditions cannot be maintained in those regions where precipitation exceeds evaporation. According to Baker, the adsorption of the dissolved solids by soil particles causes the containment pond bottom to become sealed and practically impermeable to water. This disadvantage can be partially overcome by neutralization of the waste water to reduce dissolved solids prior to lagooning.

Neutralization as a pretreatment technique has been investigated previously for phenolic, protein and urea plywood glue waste waters using alum, sulfuric acid, and hydrochloric acid as neutralizing agents. The resulting titration curves are presented in Figures 56A and 56B. These give both the volume of titrant required to produce a given pH and the optimum pH value for maximum COD reduction for the various glues. Figures 57 and 58 indicate that the maximum COD reduction occurs for both protein and phenolic resins at approximately pH 7.5. While comparable data is not available on dissolved solids, it can be assumed that a large percentage of the total COD of the waste water is because of dissolved solids and, therefore, that the maximum dissolved solids reduction would occur at near neutral pH. Tables 55 and 56 present optimum dosage levels, sludge production rates, and cost information for neutralization of protein and phenolic glue wastes. It should be noted that, for a phenol glue waste, approximately 13.8 ml of 1 N H_2SO_4 is required per gram of glue. Thus, assuming a 40:1 dilution of wash water to glue, approximately 1961 lpd (518 gal per day) of 1N H_2SO_4 would be required for a glue waste flow of 5,678 lpd (1,500 gal per day). The total volume of unthickened sludge produced from the above neutralization would be approximately 5,681 lpd (1,501 gal per day).

While the above information specifically concerns phenolic and protein glue wastes, similar, though less extensive studies have

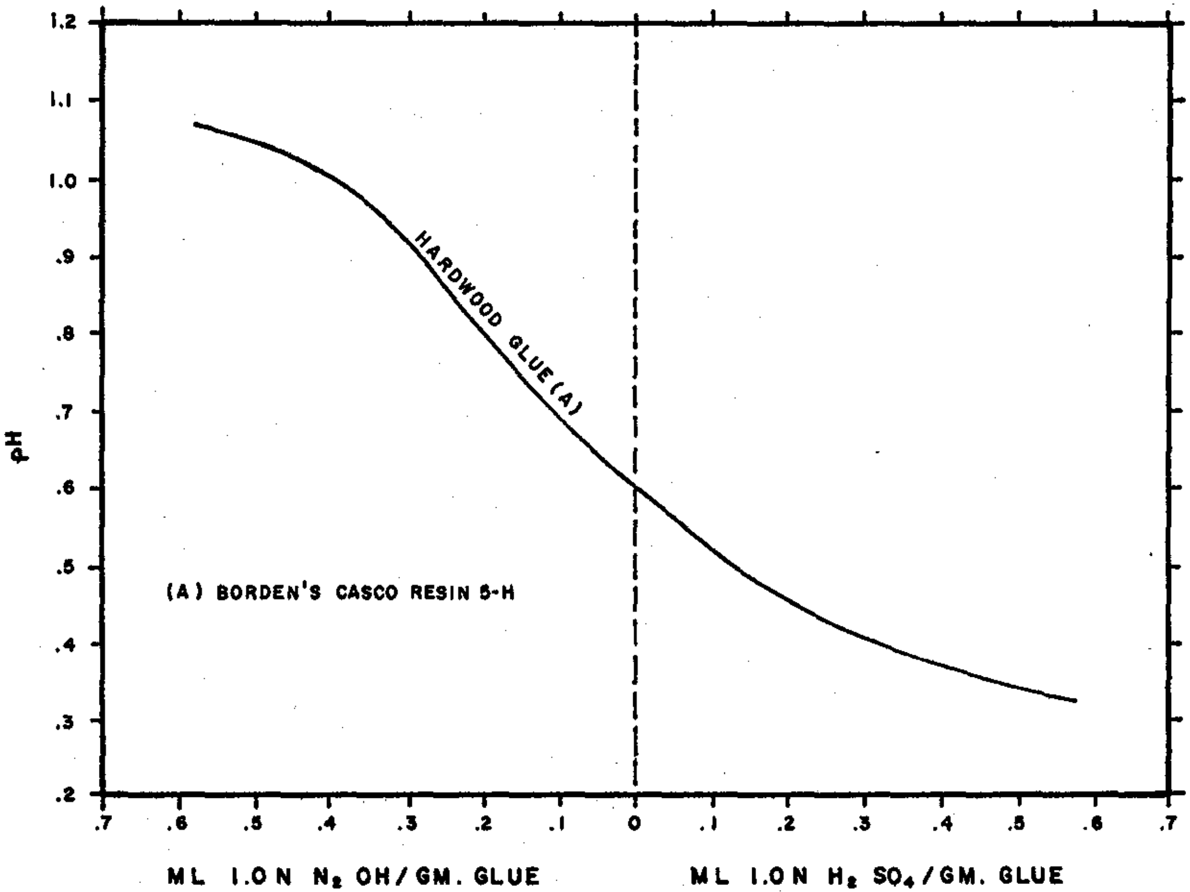


FIGURE 56A TITRATION CURVE FOR HARDWOOD GLUE

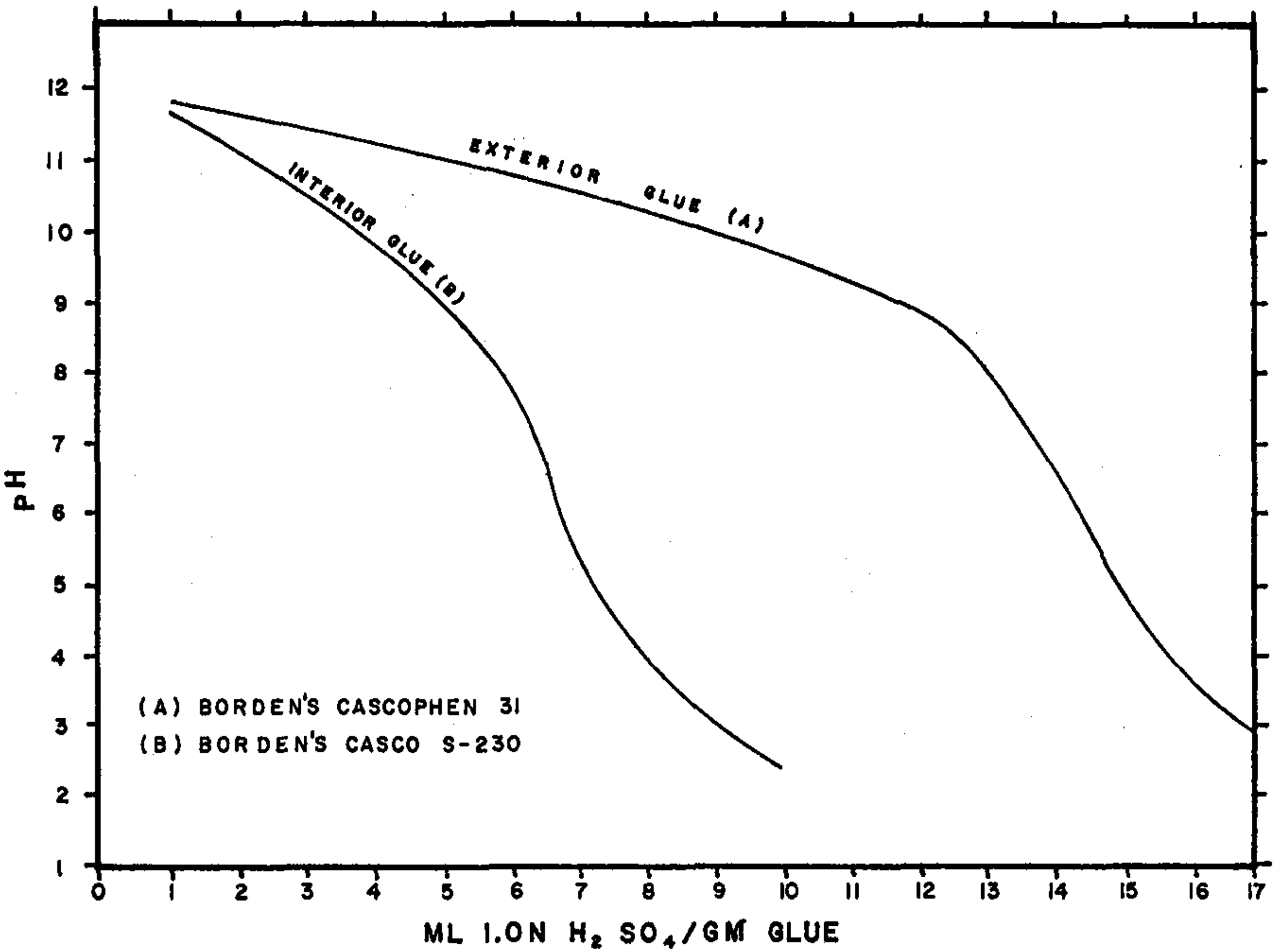


FIGURE 56B TITRATION CURVE FOR PHENOLIC AND PROTEIN GLUE

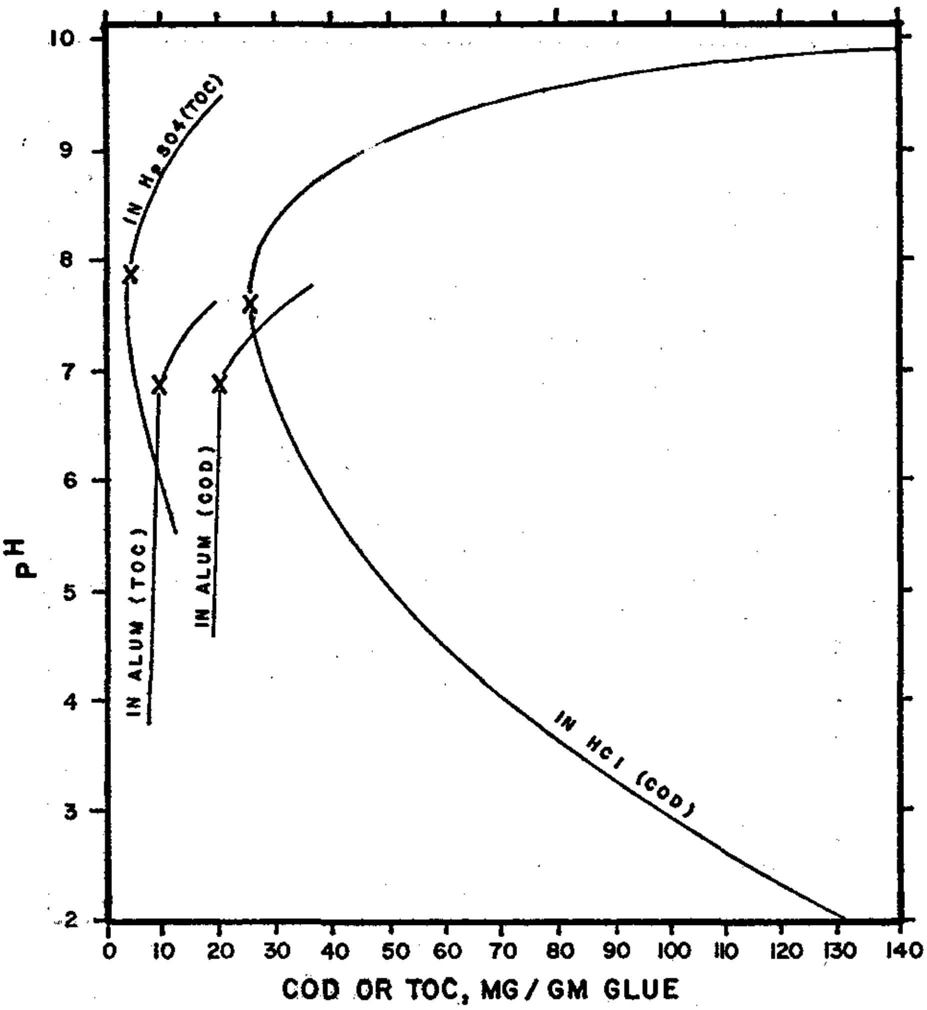


FIGURE 57. COD AND TOC OF SUPERNATANT VS pH FOR PROTEIN GLUE

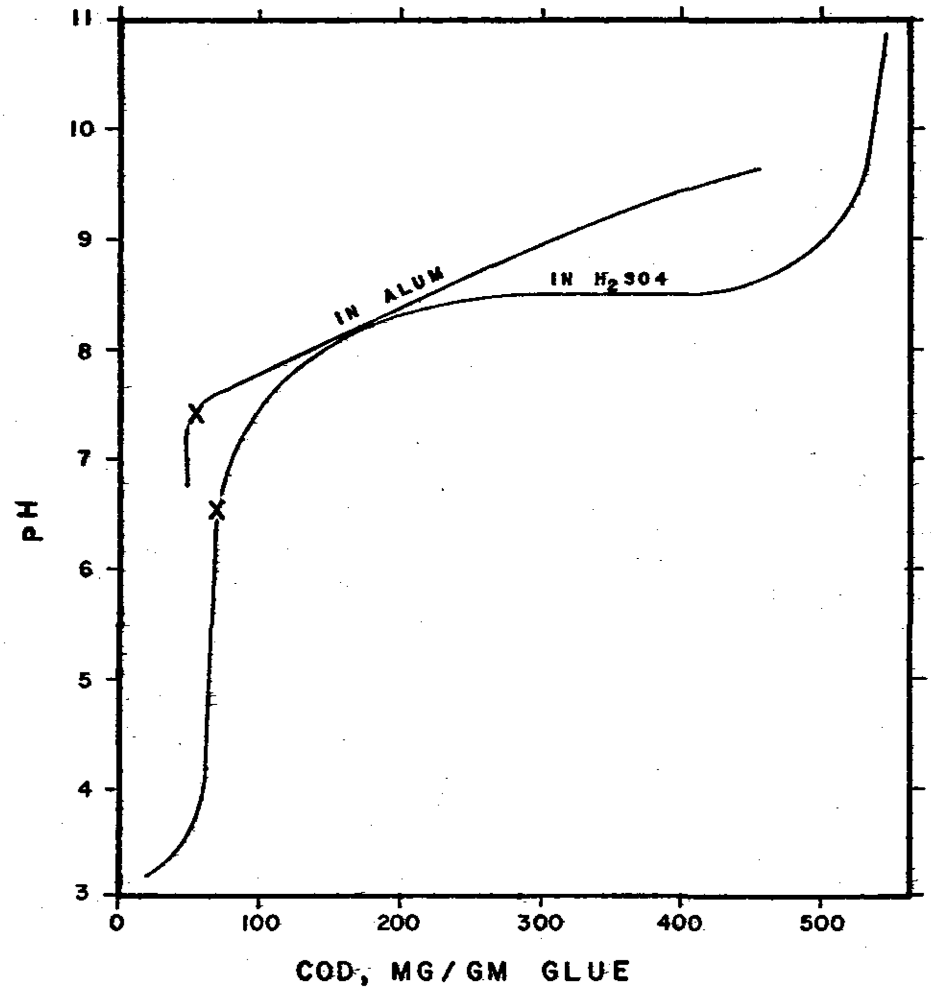


FIGURE 58 COD OF SUPERNATANT VS pH FOR PHENOLIC GLUE

TABLE 55

NEUTRALIZATION OF PROTEIN GLUE WASTE

	Acid (1N H_2SO_4)	Alum (1N $Al_2(SO_4)_3 \cdot 18H_2O$)	Acid (1N HCl)
Optimum Treatment Dosage, ml/g glue	6.3	6.7	6.2
COD supn't, mg/g glue[a]	--	19.5	26.0
TOC, supn't, mg/g glue[b]	3.2	9.0	--
pH	7.9	6.9	7.6
Cost of chemicals/ 100 Kg glue	$0.35	$0.79	$0.74

[a] Initial COD, 176,000 mg/gm glue

[b] Initial TOC, 52,000 mg/gm glue

TABLE 56

ALUM VS H_2SO_4 FOR NEUTRALIZATION OF PHENOLIC GLUE WASTE

	Acid (1N H_2SO_4)	Alum (1N $Al_2(SO_4)_3 \cdot 18H_2O$)
Optimum Treatment Dosage, ml/g glue	13.8	14.0
COD supn't mg/g glue[b/]	67.0	50.0
pH	6.8	7.4
Total gms solids produced/ g glue	0.24	0.46
Total Volume sludge, ml/g glue	40.0	60.0
Cost of chemicals/100 Kg glue	$0.77	$1.65

[b/] Initial COD, 653 mg/g glue

been performed for casein and phenol resorcinol glue wastes. The results of these studies indicate that approximately 162 lpd (44 gal per day) of 1 N $AL_2(SO_4)_3 \cdot 18H_2O$ would be required for neutralization of 5,678 lpd (1,500 gal per day) of these types of glue waste waters. These studies also indicate that the precipitate formed as a result of neutralization will have poor settling characteristics. Because of the obvious sludge handling problems discussed above, neutralization will likely not be a practicable control technology. Therefore, containment pond design should be based on zero infiltration where neutralization is not practiced. The assumption of zero infiltration assures the need for induced evaporation in areas where precipitation exceeds evaporation.

Another alternative for glue waste disposal consists of screening and sedimentation to remove settleable solids and floating debris followed by landspreading, landfill disposal or incineration. Where adequate area is available, landspreading is a satisfactory disposal method except during winter months when the ground is frozen. Previous studies as well as observations during the current study indicate that the glue solids are biodegradable by soil bacteria. While the intermittent nature of the waste water flow and the high phenolic content of many of the resins prohibits typical biological treatment of the waste water, soil bacteria appear to degrade the glue solids over a period of time.

Disposal by incineration was investigated by Bodien. His results, presented in Table 57 indicate the small percentage of non-volatile solids present in several typical plywood glue wastes. This condition is probably typical of the glue wastes encountered in fabricating operations. Data collected during the current study, as presented in Table 58, indicate that the precentage of non-volatile solids for phenol resorcinol waste waters will be small. The conclusion can be drawn that incineration of glue wastes at temperatures exceeding 600 C would be a highly efficient method of reducing the volume of wastes. Thus, where incineration facilities presently exist such as at sawmills with hogged fuel furnaces, spraying the glue waste water on the hogged fuel prior to burning would constitute a practicable control technology and would result in a negligible increase in ash presently produced.

A third alternative consists of screening and sedimentation of the waste water followed by reuse of wash water for future equipment cleaning. While this control method is being utilized in the plywood industry, it is not known whether its application would be practicable for all industrial glue wastes. This method would probably require closer operational control than previous control technologies so as to avoid clogging the recycle pump or piping. Apparent advantages in the application of such a recycle system include the fact that no reliance need be made on hydrological conditions to insure proper control of disposal as is the case with containment and land spreading. Reuse of the waste water for washing may also serve to emphasize conservation

TABLE 57

INCINERATION TEST FOR PHENOLIC, PROTEIN AND UREA GLUE

	Based on Wet Weight of Glue		Based on Dry Weight Glue Solids	
	% Ash @ 600°C	% Ash @ 1000°C	% Ash A 600°C	% Ash @ 1000°C
Phenolic	4.58	4.12	26.08	23.40
Protein	13.37	6.12	34.48	15.76
Urea	Nil	Nil	Nil	Nil

TABLE 58

VOLATILE SOLIDS IN PHENOL RESORCINOL WASTEWATER

	Total Solids (mg/l)	Total Volatile Solids (mg/l)	Non-Volatile
Sample A	1284	886	30
Sample B	5917	5116	14
Sample C	1013	796	21

practices because of the limited amount of storage provided in the system and the increased costs of excessive water usage.

For some resins, a portion of the waste water may be used as makeup for the next batch of glue. This may be the case with various resins delivered in a dry powder form. However, the practicality of waste water recycle for glue mixing is not established for resins other than those utilized in the plywood industry. Table 59 presents a comparison of anticipated wash water flows and potential reuse of the waste water for glue mixing of viscosity control.

A fourth alternative for disposal and a common practice is discharge to municipal sewers. The majority of resins may be considered compatible with municipal sewage treatment plants either because the constituents of the waste waters are biodegradable, because the volume is small, or both. Some constituents may not be compatible, however, if discharged in large slugs. This is the case, for instance, with the phenolic resins which may contain over 500 milligrams of phenols per kilogram of glue while phenol resorcinol resins may contain 4 to 18 percent free phenol. Many protein glues contain sodium pentachlorophenate as an inhibitor at levels up to 0.5 percent. Other types of resin may contain catalysts such as chromium nitrate at levels up to 5 percent by weight. Metals such as these may pass through a conventional secondary treatment system.

Selected Treatment Alternatives for Model Plants

On the basis of the above discussion, five alternative treatment systems have been developed for glue wastes resulting from the two fabrication operations modeled in Section V.

Alternative A consists of no treatment and control and results in no reduction benefits or costs.

Alternative B consists of screening and discharge to a spray evaporation pond. Screening is accomplished in this and all remaining alternatives by a 38 cm (15 in) rotating screen with 2.00 mm (0.1 in) screen openings. The screened effluent is then discharged to a pond sized such that spray evaporators operating five months per year contain the waste flow and rainwater completely. The evaporators consist of a pump, piping, spray nozzles, and a flotation system. A schematic of the system is presented in Figure 59. Table 60 presents design information concerning the proposed treatment system.

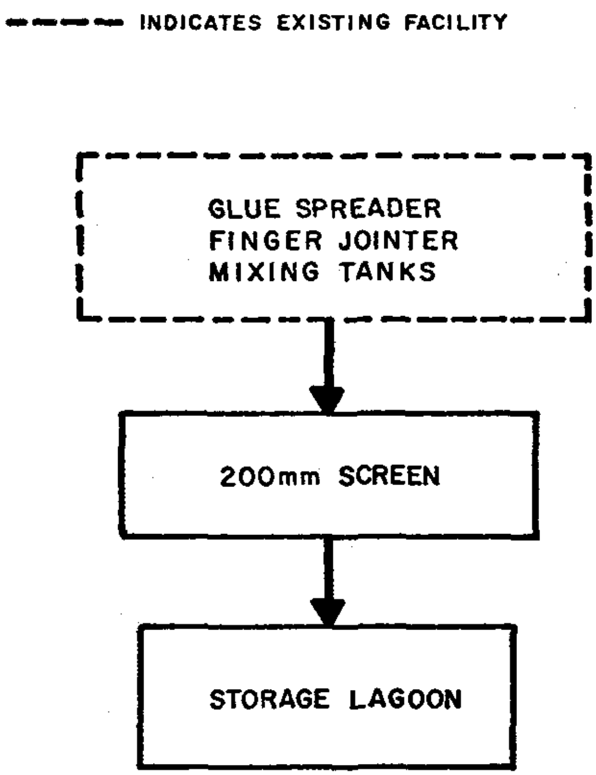
Alternative C, incineration, consists of screening, storage and the necessary pump and piping to spray the wastes onto hogged fuel prior to burning. This alternative assumes the existence of a hogged fuel furnace.

Alternative D, landspreading of the glue wastes, consists of screening, storage and trucking to landspreading or landfilling. A schematic of Alternatives C and D is given in Figure 60.

TABLE 59

POTENTIAL MAKEUP WATER VS. WASTEWATER PRODUCTION

Mill	Type of Product	Type of Glue	Wastewater Production (l/day)	Potential Makeup Water (l/day)
A	Garage Door	Polyvinyl	380	4
	Beams	Phenol Resorcinol	190	19
	End-Jointed Lumber	Polyvinyl	190	4
B	Beams	Phenol Resorcinol	380	68
C	Beams	Phenol Resorcinol	4500	
	Decking	Phenol Resorcinol		125
	End-Jointed Lumber	Phenol Resorcinal	2300	
D	Decking	Melamic Urea	3800	110



PLANT - I

FLOW = 757 lpd

SPRAY EVAPORATION WHERE NECESSARY

PLANT - 2

FLOW = 5678 lpd

SPRAY EVAPORATION WHERE NECESSARY

FIGURE 59 ALTERNATIVE B FOR GLUE WASTE DISPOSAL

TABLE 60

SPRAY EVAPORATION POND DESIGN ALTERNATIVE B

<u>Northwest Region</u>

Precipitation - 259 cm/year
Evaporation - 61 cm/year

<u>Plant 1</u>

Flow - 760 liters/day
Lagoon Size - 11 x 11 x 3 meters deep
Spray Evaporators - One twenty horsepower unit, operating six hours per day, five months per year.

<u>Plant 2</u>

Flow - 5680 liters/day
Lagoon Size - 30 x 30 x 3 meters deep
Spray Evaporators - One seventy horsepower unit operating eleven hours per day, five months per year.

<u>North Central Region</u>

Precipitation - 84 cm/year
Evaporation - 76 cm/year

<u>Plant 1</u>

Flow - 760 liters/day
Lagoon Size - 9 x 9 x 3 meters deep
Spray Evaporators - One twenty horsepower unit, operating three hours per day, five months per year.

<u>Plant 2</u>

Flow - 5680 liters/day
Lagoon Size - 23 x 23 x 3 meters deep
Spray Evaporators - One seventy-five horsepower unit, operating six hours per day, five months per year.

<u>New England Region</u>

Precipitation - 94 cm/year
Evaporation - 64 cm/year

<u>Plant 1</u>

Flow - 760 liters/day
Lagoon Size - 8 x 8 x 3 meters deep
Spray Evaporators - One twenty horsepower unit, operating three hours per day, five months per year.

<u>Plant 2</u>

Flow - 5680 liters/day
Lagoon Size - 22 x 22 x 3 meters deep
Spray Evaporators - One seventy-five horsepower unit, operating six hours per day, five months per year.

Southwest Region

Precipitation - 38 cm/year
Evaporation - 147 cm/year

Plant 1

Flow - 760 liters/day
Lagoon Size - 11 x 11 x 0.6 meters deep
Spray Evaporators - One twenty horsepower unit, operating 1.5 hours per day, five months per year.

Plant 2

Flow - 5680 liters/day
Lagoon Size - 30 x 30 x 0.6 meters deep
Spray Evaporators - One twenty horsepower unit, operating eleven hours per day, five months per year.

Southeast Region

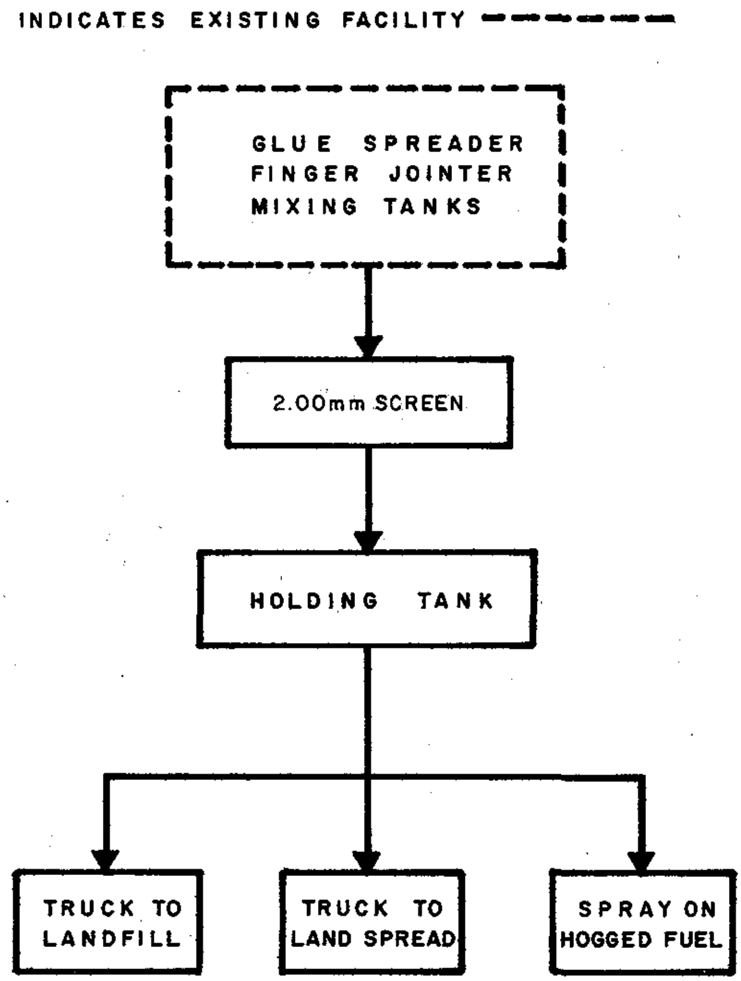
Precipitation - 127 cm/year
Evaporation - 112 cm/year

Plant 1

Flow - 760 liters/day
Lagoon Size - 8 x 8 x 3 meters deep
Spray Evaporators - One twenty horsepower unit, operating twenty hours per day, five months per year.

Plant2

Flow - 5680 liters/day
Lagoon Size - 21 x 21 x 3 meters deep
Spray Evaporators - One seventy-five horsepower unit, operating six hours per day, five months per year.



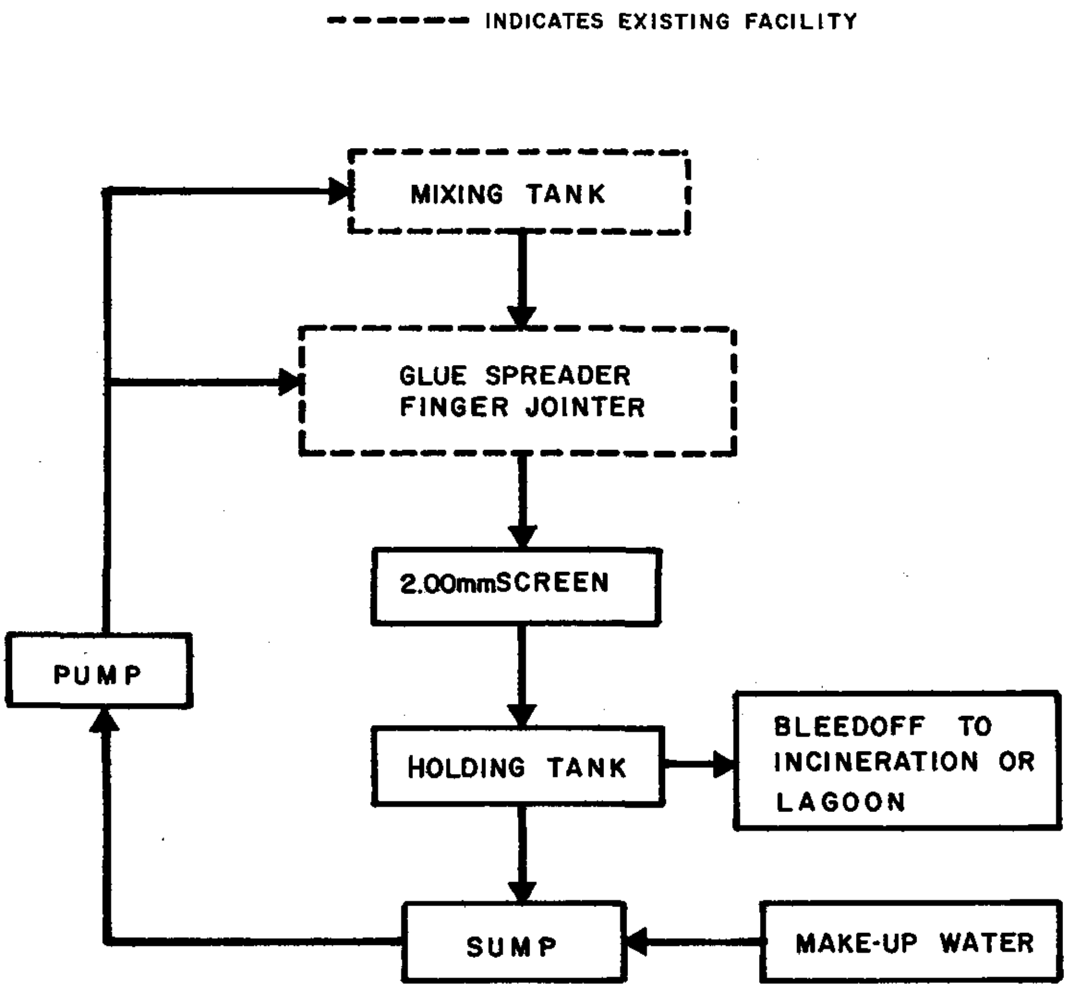
PLANT - 1

FLOW = 757 lpd
HOLDING TANK VOLUME = 7570 liters

PLANT - 2

FLOW = 5678 lpd
HOLDING TANK VOLUME = 37,850 liters

FIGURE 60 ALTERNATIVES C AND D FOR FABRICATION



PLANT – 1

PUMP FLOW = 757 lpd @3.7atm (INTERMITTENT)

HOLDING TANK VOLUME = 3785 liters

PLANT – 2

PUMP FLOW = 5,678 lpd @ 3.7atm (INTERMITTENT)

HOLDING TANK VOLUME = 18,925 liters

FIGURE 61 ALTERNATIVE E FOR GLUE WASHWATER REUSE SYSTEM

Alternative E, wash water recycle, again consists of screening and storage. The settled and screened effluent is then utilized for subsequent washing operations. A sump and sump pump are provided as is a capacity for makeup water to the system and bleedoff from the system. Provision is also made for use of the waste water in glue mixing where feasible. This system is presented in Figure 61.

Alternative F is applicable for urban fabricating operations and consists of discharge to a municipal sewer.

INSULATION BOARD

The treatment and control method currently in use in all plants consists of primary clarification only. Other systems in use include activated sludge, aerated lagoons, spray irrigation, sedimentation, coagulation, and water recycle. There are also two plants currently discharging into municipal treatment systems, with three others scheduled to do so in the near future.

Inplant Control Measures and Technology

There are various means by which waste water flow and loading from an insulation board plant may be reduced. However, some of these methods are either not practical or not applicable to every plant because of variations in inplant processes or products produced. As discussed previously in Section V, and shown graphically in Figure 40, steaming pressure, and time have an influence on the BOD loading from a given process. While the reduction of the severity of steaming may reduce waste water loads, there is a counter-effect of increased cost of defibrating as well as a decrease in the quality of the resulting fiber. Full scale plant tests in Sweden have shown a BOD load reduction of up to 50 percent with reductions of steaming pressures from 15 atmospheres to approximately 7 atmospheres.

Studies in Sweden on the economics of decreasing steaming severity show that there is an approximate increase of up to $1.50 per metric ton when the steaming pressure is reduced by this amount. Although these costs may differ from one plant to another depending on the extent of modification of existing equipment, they are considered sufficiently valid to reflect the increase in energy consumption, the purchase of extra refining equipment, and the reduction of steam consumption.

It was also found in the study that there is a decrease in internal bonding strength in the finished board when steam reduction is done outside of certain ranges. It was concluded that the quality of pulps produced within a range of six to twelve atmospheres of steam pressure (70 to 160 psi) are about the same; however, reduction in steaming pressure below this range produces fiber of lower quality. In addition to a decrease in the internal bonding properties of the board, there has also been noted a decrease in the resistance to water absorption and an increase in swelling properties of the final board. Most plants in the U. S. already operate below 11 atmospheres, therefore, they are discharging less BOD load than if they were operating at a higher steaming pressure.

The elimination of steaming completely (or the reduction of steam pressures to under two atmospheres (29 psi) cannot be considered a viable alternative to reduced waste water loads as this will change the characteristics of the fiber produced which in turn will affect the following operations and have considerable effect on the final product. In addition, there are certain species of wood such as oak which could no longer be utilized if steaming were to be eliminated. Therefore reductions or elimination of steaming on an industry-wide basis is not considered an alternative for BOD reduction, although each plant may want to consider it on an individual basis.

As discussed in Section V, all insulation board plants practice some degree of process water recirculation. It is also typical of the industry to practice some degree of reuse of other waters.

The major effect of closing a process water system is the reduction of the total amount of suspended solids (fibers and other fine suspended substances) in the discharge stream. It has been shown that the concentration of suspended solids in the waste water is approximately the same regardless of the total volume of waste water discharged. Thus the total pounds of fibers and other suspended substances discharged will be roughly proportional to the volume of the waste water discharged.

Although it has been shown that plants with closed water systems have lower pollution loads than plants with open systems, only when a process water system is closed to a discharge of less than 2000 l per metric ion (500 gal per ton) will a significant decrease in BOD load occur. A decrease in the volume of waste water discharged from 50,000 l per metric ton to 10,500 l per metric ton (12,000 gal per ton to 2,500 gal per ton) reduces the amount of solubles (the major contributor to BOD) by only eight percent in the waste stream. Plants in the U. S. usually recycle water by such systems as are shown in Figures 62 and 63.

There are limitations to the amount of recirculation which can be done by any given plant. When a process water system is closed, there is usually a buildup of dissolved solids and, to a small extent, suspended solids, as well as a decrease in pH and an increase in temperature of the process water system. These factors affect both the economics of the process and the quality of the final product. Also, as these effects occur, there is further hydrolysis of some of the dissolved solids to lower molecular weight material, thus increasing the BOD per unit mass of dissolved solids by hydrolyzing the colloidal fiber into a dissolved state. The dissolving of the colloidal fiber would eliminate any possibility of a substantial portion of it being removed by chemical coagulation.

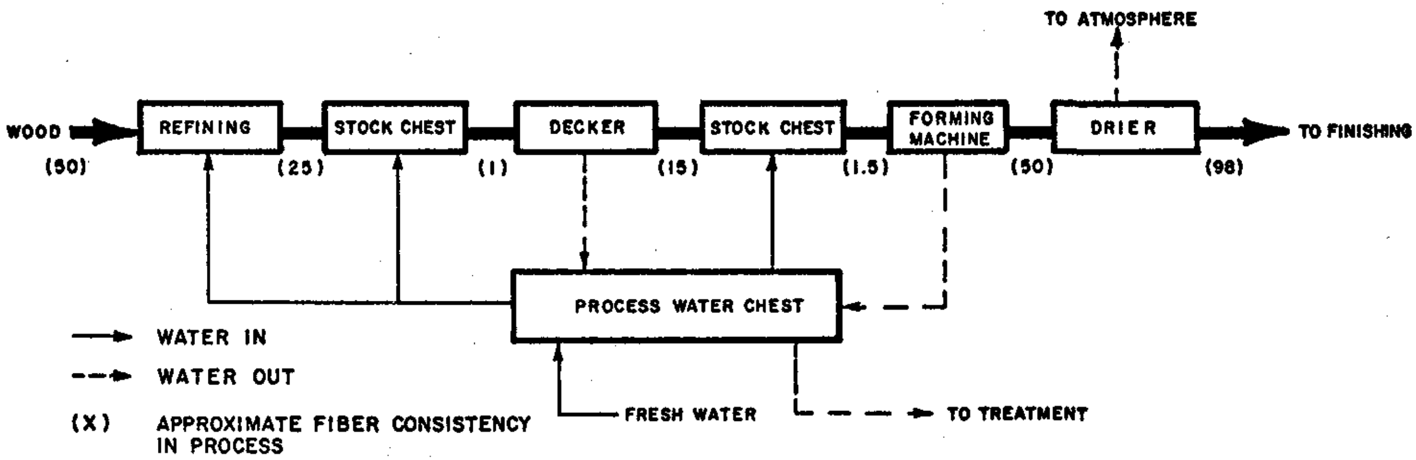


FIGURE 62 WATER RECYCLE SYSTEM TYPE I FOR INSULATION BOARD

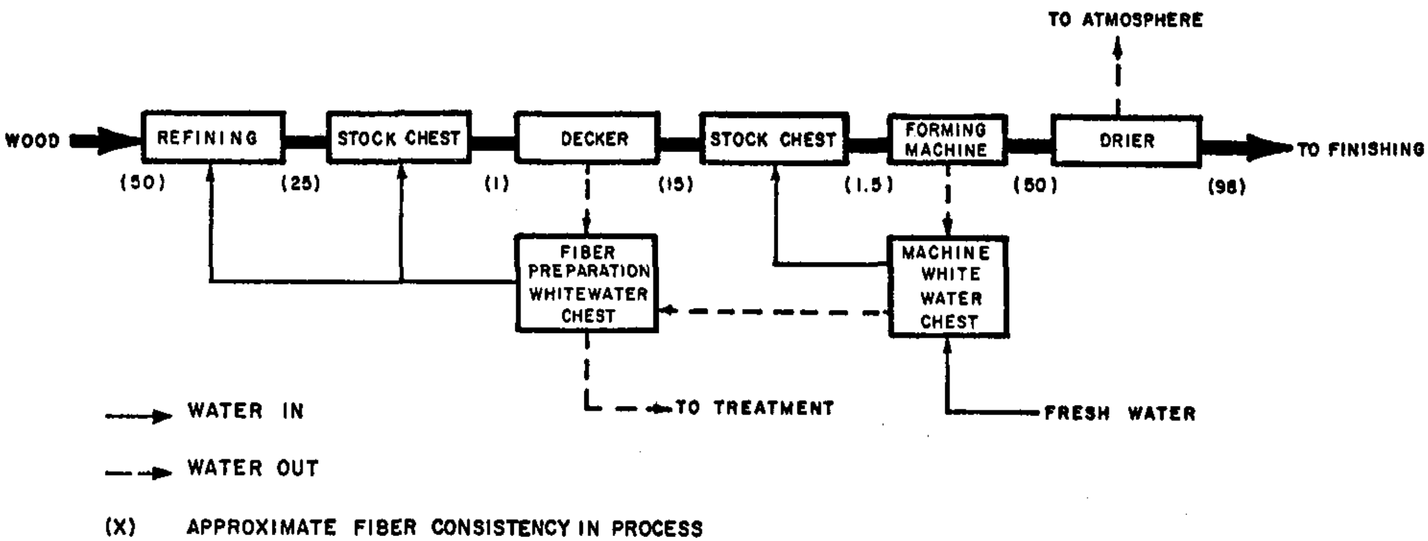


FIGURE 63 WATER RECYCLE SYSTEM TYPE II FOR INSULATION BOARD

As the process water system is closed, there is an increase in the concentration of soluble substances (dissolved solids) of both organic and inorganic nature. Because there is over 50 percent moisture in the mat entering the dryer, a higher concentration of dissolved solids in the process water would mean a proportional increase in the amount of dissolved matter leaving with the board. During the drying operation, there is a tendency for the wood sugar and other dissolved organics to migrate to the surface of the board. The presence of these soluble organics on the surface of the board causes problems when a dry board is coated. When a dissolved solids concentration reaches a certain point, the amount of organics on the surface of the board is so great that when a coating is applied, a discoloratión may occur.

The presence of these dissolved organic materials on the surface will cause problems during the rehumidification stage of the process. In some plants, the board is coated with a spray of water and then sheets are stacked on top of one another to allow the moisture to become uniformly distributed within the board. When the amount of organic material on the surface is too large, a lamination between boards causes entire stacks of board to stick together. A buildup of inorganic dissolved solids in a system may cause a case hardening effect in the board as it is dried. That is, there will be a less efficient utilization of heat in the dryer and more energy will be required to reduce the moisture content in the board to the required level. It has been noted in one plant, which is currently in the process of attempting to close its process water system, that an increase in weight of the board occurs and also the water resistance is decreased, thus creating a need for more size to be added to the final product. The critical amount of dissolved solids that can be tolerated by any given plant will vary considerably. It has been reported by industry that the maximum concentrations of organic dissolved solids that can be tolerated range from 0.5 percent to as high as 1.8 percent, depending on the plant involved. In general, a higher concentration of dissolved solids can be tolerated in sound deadening board as compared with sheathing board and a higher concentration can be tolerated in sheathing as compared to finished products. Those plants producing hardboard, in addition to the above problems, encounter sticking in the press when the dissolved organic concentration is excessive. The concentrations that can be tolerated by these systems will also range from approximately 0.5 percent to about 1.8 percent.

As mentioned above, there is an increase in temperature when the process water system is closed. The increase in temperature may cause hot and humid conditions near the forming machines and lead to unpleasant working conditions. The high temperature may also affect the additives that are added to some boards. For instance, when molten asphalt is added in sheathing production, it usually becomes crystalline when it contacts the process water stream. It is necessary that this occur in order to produce sheathing of high quality. However, if the temperature of the process water becomes too high, the asphalt remains in a molten state causing a degradation of product quality. Increasing recycle not only increases the temperature but causes a drop in pH. Aside from the increase of chemical hydrolysis as discussed above, a drop in pH to approximately 4.0 increases corrosion of pipes and other machinery.

A closed process water system is a media that encourages biological growth. It has been noted that slime growth occurring on screens throughout the system affects the forming operation and other screening necessary in the process. Slime buildups on machinery other than screens may be broken off and formed into the mat. When the mat is dried the slime causes an imperfection in the board and sometimes causes a cavity to appear. This again makes the board unsalable.

Although the actual concentration of suspended material may not increase significantly in a closed white water system, the percentage of fine material will. The buildup of these fine suspended solids causes a decrease in the draining rate of the stock. This will cause a slowing down of the production process, or an increase in the weight of the board. This is an undesirable effect since the board is sold on a square foot basis and shipped on a weight basis.

In a plant producing multiple products on multiple lines with a common pulping system, there are further restrictions on the reuse of process waters. This is because of an incompatibility of certain additives used in producing one product with another product. In general, as shown in Figure 64, the process waters from the finished board (ceiling tile, etc.) and mineral fiber white water systems are interchangeable and can be utilized in all other product water mixes. The process water from a hardboard machine can be utilized in the process water of a sheathing machine and sound deadening board. The process water from sheathing production can be utilized only in making sound deadening board.

Despite the limitations mentioned above, there are methods to increase the amount of water that can be recycled which in turn reduces the waste water flow and, in some cases, the pollutant load as well.

One method of achieving a decrease in waste water flow is to use a split recycle system as shown in Figure 63. This system breaks the water usage at the decker with the fiber preparation white water being held separate from the machine white water system. This system enables the reduction of pollutant flows but not necessarily the waste water loads from a process. The principle of this system is to keep the dissolved solids that are released during the steaming process from entering the machine white water system. This enables a plant to reduce the waste water discharge, which might be advantageous for spray irrigation, to concentrate the waste water stream if evaporation is being considered, or to reduce the flow and save money on clarifier costs, if a biological system is to be used, while at the same

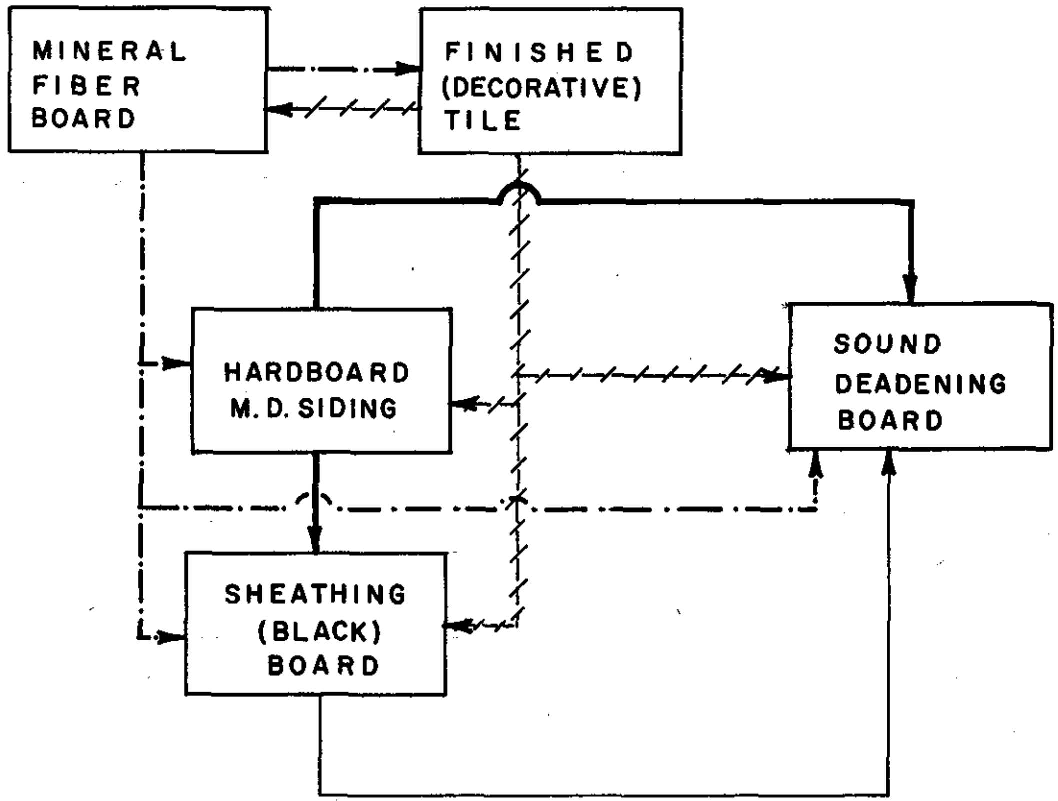


FIGURE 64 COMPATIBILITY OF PROCESS WATERS OF VARIOUS PRODUCTS - INSULATION BOARD

time control the dissolved solids concentration being built up in the machine white water system. This would eliminate or greatly reduce the problems associated with dissolved solids buildup in the machine white water system discussed above. There are limitations to this system. It is not applicable for a multi-product, multi-line plant which uses a combined pulping system, as recycled water from the sheathing line may come in contact with the fiber destined for the ceiling boardline, thus contaminatng the board. If separate pulping systems are used this is not a problem. There is the possibility for an increase in temperature and lowering of pH in the fiber preparation white water system. This can be eliminated by using stainless steel piping and installing a heat exchanger.

Another method of reducing water discharge is to use a primary clarifier and recirculate a portion of the clarified water back to the system. This is currently being done in a number of hardboard and insulation board plants with promising results.

There is also some pilot scale work being conducted on the use of coagulants and flotation clarifiers to enable a more closed system to be achieved. The use of calcium hydroxide, followed by aluminum sulfate with a high ferric sulfate content has been shown to reduce the chemical oxygen demand of process water systems by about 30 percent over a rather wide range of pH conditions. This reduction is principally the result of the removal of some of the higher molecular weight dissolved organics. Various coagulation processes have been tried both in the U. S. and Europe in an attempt to increase recycle and reduce BOD loads. The results have not been particularly successful with only a small percentage of the plants installing a full scale process.

Other methods for increasing the amount of water that can be recycled by attempting to remove the suspended solids. These include 1) the use of a Saveall or 2) a diatomaceous earth filter. The diatomaceous earth filter utilizes coagulation to increase solids removal by the filter. Solids reduction from 2000 or 3000 mg/l down to 200 or less are reported to be common. The practical application of this system has not been adequately tested, but it can be assumed that it can be used to reduce the waste water discharge. A schematic of a summary of the above treatment systems is shown in Figure 65.

There is currently one plant recycling secondary effluent to the process and another plant planning to do pilot work in the near future. In these systems, the effluent from the plant goes through a biological treatment system (activated sludge) and the effluent from the secondary clarifier is recycled to the process. The use of a biological treatment system enables a considerable reduction in the organic material in the waste stream. A system of this type would reduce limitations imposed by high concentrations of dissolved solids of organic nature. However, the plant currently recycling from the secondary clarifier has no long term data and thus the effect of the buildup of inorganic

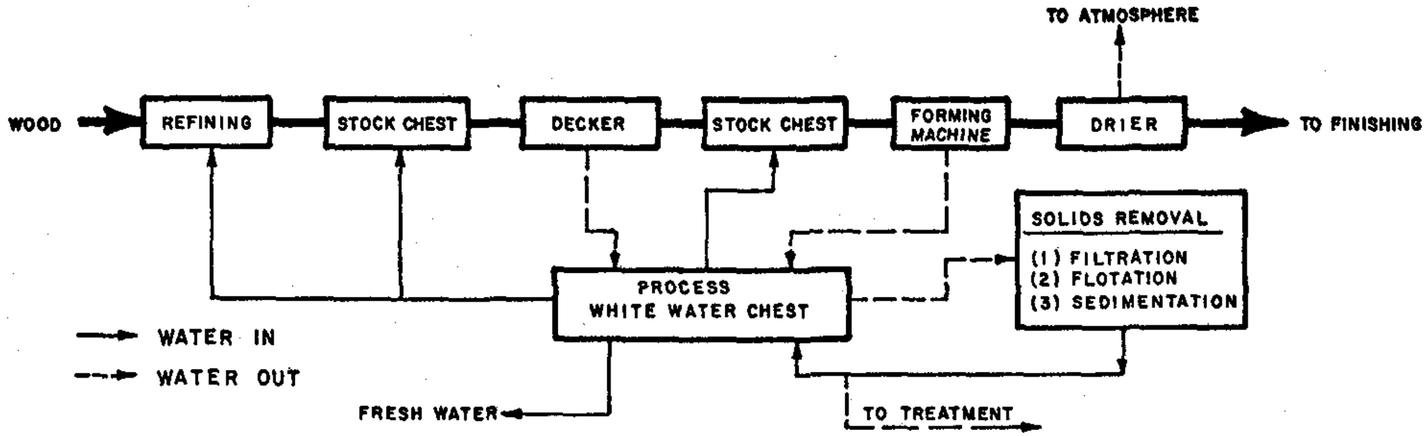


FIGURE 65 SCHEMATIC OF SUSPENDED SOLIDS REMOVAL FOR PROCESS WHITE WATER RECYCLE IN INSULATION BOARD PLANTS

dissolved solids has not been adequately studied. Members of the industry indicated that recycle of a portion of the secondary effluent is a practical idea. However, the problems of suspended solids overflowing the clarifier must be solved, possibly by mixed media filtration. The effect of the buildup of inorganic solids on a long term basis must be studied before a large scale utilization of this scheme is employed.

There are other possible places where water may be reused in a system to reduce water usage. These include but are not limited to the use of cooling water and seal water as process makeup water and the reuse experimentally of clarified effluent from a primary or secondary clarifier as seal water. A summary of water reuse possibilities is presented in Figure 66 for a typical plant.

End-of-Line Treatment Technology

Existing end-of-line waste water treatment technology in the insulation board industry varies considerably within the industry. There are plants with no treatment and plants with zero discharge. The existing systems can be considered conventional and usually consist of primary clarification followed by a type of biological treatment. Each of the existing processes presently being used is discussed below and presented in Table 61.

Primary Sedimentation - The removal of suspended solids by primary sedimentation is the basic process utilized for waste water treatment in most plants. At least 13 plants utilize primary settling tanks or ponds as part of their treatment system. Overflow from primary settling may be discharged to receiving streams, to municipal treatment systems, or to further treatment on site. A portion of the overflow may also be recycled for inplant use. Suspended solids removal efficiency data are available from only two insulation board plants which report approximately 50 and 85 percent efficiency, respectively. Because most of the BOD in the waste water from an insulation board plant is dissolved solids, BOD removal by primary sedimentation is only approximately 10 percent.

Handling of sludge from the primary settling units is a major problem. Some plants reuse a small portion of the sludge in the production of board; however, the quantity of sludge reused is dependent on many factors and is not a dependable method for sludge handling. Therefore, adequate means of sludge handling must be available at all plants. The only mechanical sludge dewatering process reported to be used in the insulation board industry is vacuum filtration. Final sludge disposal with or without prior dewatering usually consists of lagooning or land disposal.

Activated Sludge - Three plants are utilizing activated sludge systems for a portion of their waste water treatment. Table 62 shows the average efficiency of these treatment systems. Average

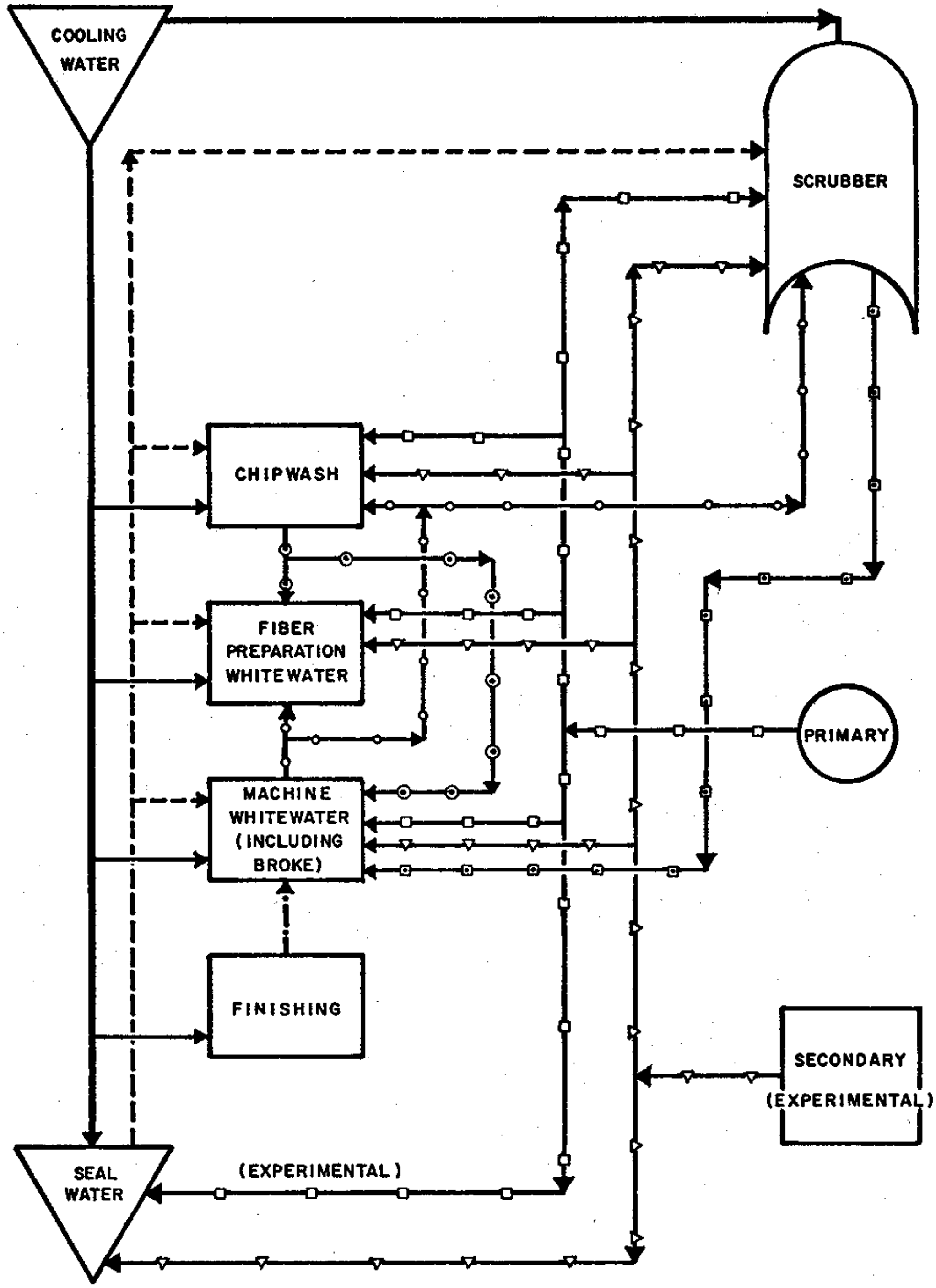


FIGURE 66 WATER REUSE POSSIBILITIES FOR AN INSULATION BOARD PLANT

TABLE 61

EXISTING TREATMENT TECHNOLOGY IN THE INSULATION BOARD INDUSTRY

PLANT NO.	EXISTING WASTEWATER TREATMENT
1	To Municipal System
3	Spray Irrigation
4	Primary Settling
5	Primary Settling, Spray Irrigation, or Lagoon
6	Primary Settling
7	Primary Settling, Activated Sludge
9	Primary Settling
10	Diatomaceous Filter*
11	None
12	Primary Settling, Activated Sludge
13	None
14	Primary Settling, Aerated Lagoon, Lagoon
15	Spray Irrigation
16	Aerated Lagoon, Secondary Clarifier*
17	To Municipal System
18	Primary Settling, Lagoon*
19	Primary Settling, Lagoon, To Municipal System
20	To Municipal System

*These systems involve experimentation with complete reuse of the treatment system's effluent.

TABLE 62

EFFICIENCY OF BIOLOGICAL TREATMENT PROCESSES

	INFLUENT		EFFLUENT				
Plant	BOD Kg/KKg	SS Kg/KKg	BOD Kg/KKG	BOD Removal Eff.	SS Kg/KKg	SS mg/l	SS Removal Eff.
			Activated Sludge				
7	11.6	11.8	2.6	78%	24.5	1027	0%
9	15.1	14.1	2.8	83%	4.2	359	70%
12	15.1	4.2	1.4	91%	3.9	424	8%
			Aerated Lagoon				
16*	6.5	.7	0.5	94%	0.2	68	77%
14	44.6	52.3	2.8	94%	1.0	98	99%

* 50+ Day D.T.

BOD reductions vary from 78 to 91 percent and suspended solids reductions vary from zero to 70 percent. There is little question that a properly designed and operated activated sludge system can provide an average BOD reduction of 90 percent. At least two hardboard mills which have similar waste water characteristics are achieving greater than 95 percent BOD removal with activated sludge processes.

The efficiency of biological systems for removing suspended solids appears quite low because of the high concentrations of biological suspended solids in the effluent and the fact that these solids are difficult to settle and dewater. There is presently no economical method that is satisfactory for handling waste activated sludge generated by insulation board waste water treatment systems. The difficulty of handling waste solids causes a build up within the treatment system, a resulting discharge of solids in the effluent, and the characteristically low efficiency of the system for suspended solids removal. Furthermore, ambient temperature are reported to have an effect on the settling rate of biological solids in biological treatment systems.

Figures 67, 68, 69, 70, and 71 show the variation in the monthly average effluent BOD and suspended solids for plants 7, 9, 12, 14, and 16, respectively. The major significance of these figures is the illustrated variation in effluent composition and high suspended solids in the effluent.

<u>Aerated Lagoons</u> - Two plants report utilization of aerated lagoons as part of a waste water treatment system. Plant 16 has an aerated lagoon followed by a clarifier and plant 14 has an aerated system followed by lagoons. As shown in Table 62, the treatment efficiency across the total process for both of these plants average 94 percent BOD removal and greater than 75 percent suspended solids removal. Both of these plants are located in areas where winter temperatures are quite cold. It should be noted that although these two systems are technically aerated lagoon systems, the design parameters utilized for constructing the systems are completely different.

<u>Lagoons</u> - Lagoons are utilized by six plants as part of their waste treatment system. Lagoons serve as holding ponds to dampen variations in waste water flow and concentration, to hold waste water during winter months when spray irrigation fields are frozen, to serve as settling ponds for removal of excess solids from activated sludge or aerated lagoon processes, or simply to provide for additional BOD removal. Because of the long detention times required, lagoons are not used as a waste treatment system alone, but are quite effective as a part of other systems. Because of the wide variations of waste flow and concentrations because of inplant spills, clean-up, or equipment malfunction, lagoons will continue to serve as an effective waste water treatment process in the insulation board industry.

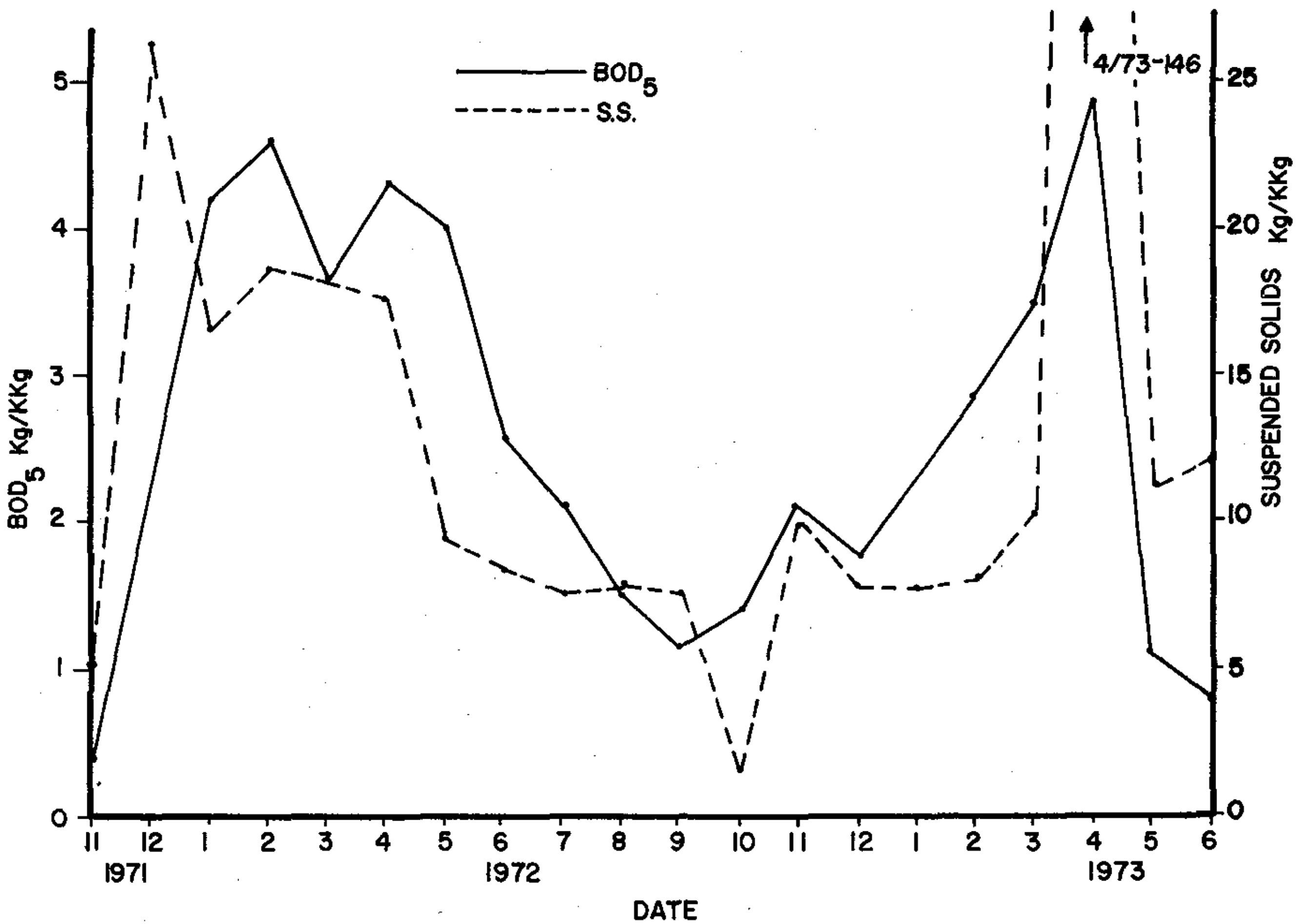


FIGURE 67 VARIATION IN BOD AND SUSPENDED SOLIDS FROM SECONDARY TREATMENT IN PLANT NO. 7

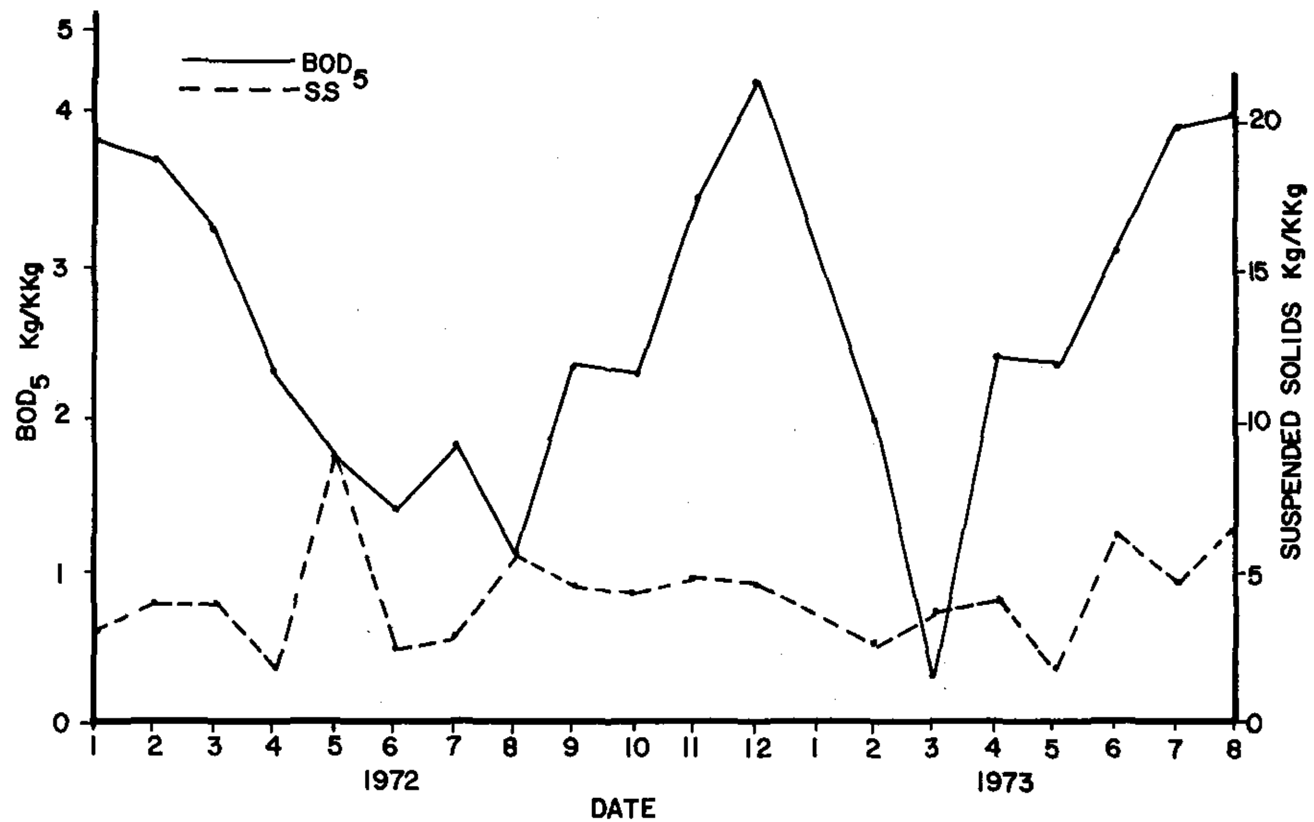


FIGURE 68 VARIATION IN BOD AND SUSPENDED SOLIDS FROM SECONDARY TREATMENT IN PLANT NO.9

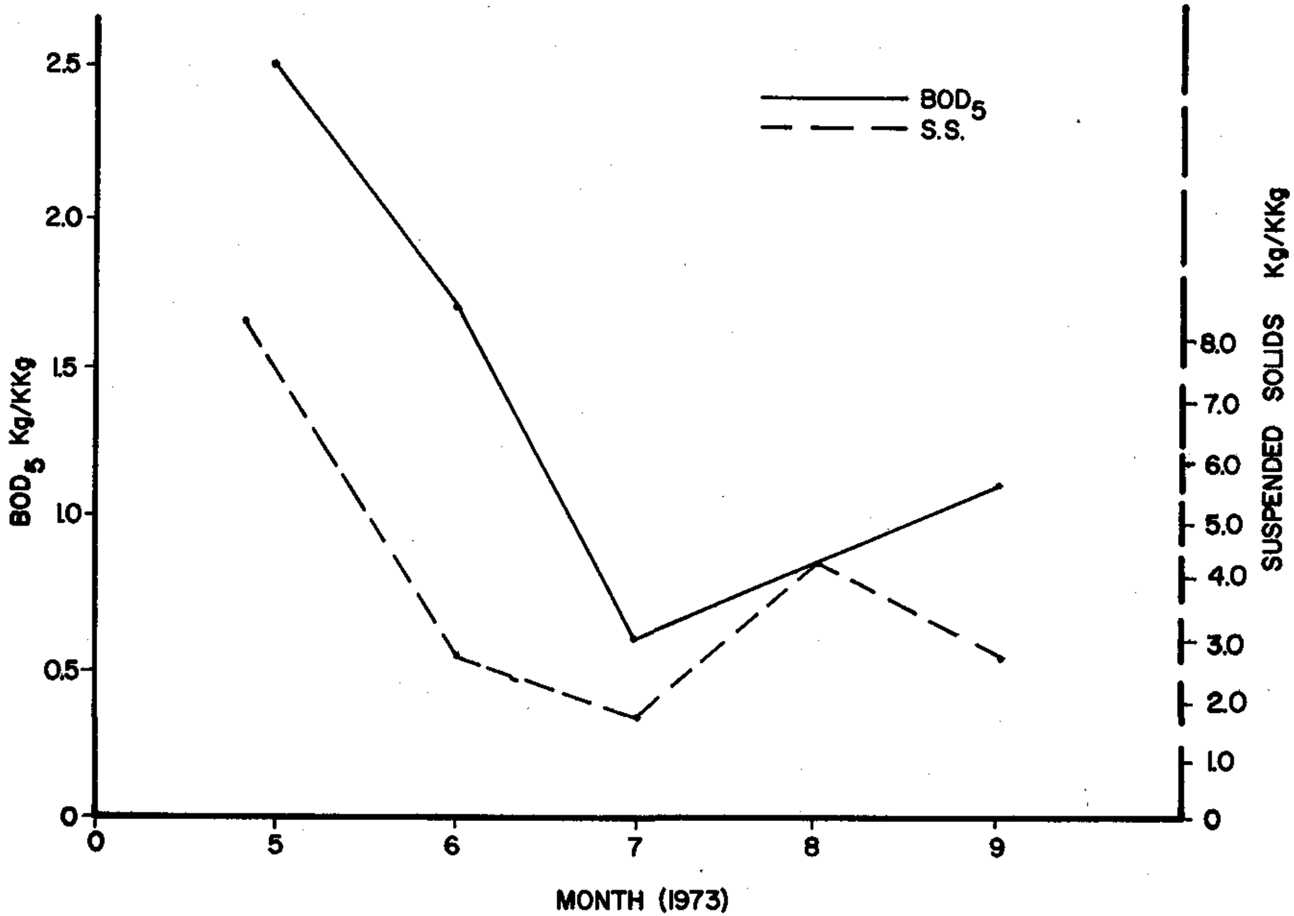


FIGURE 69 VARIATION IN BOD AND SUSPENDED SOLIDS FROM SECONDARY TREATMENT IN PLANT NO. 12

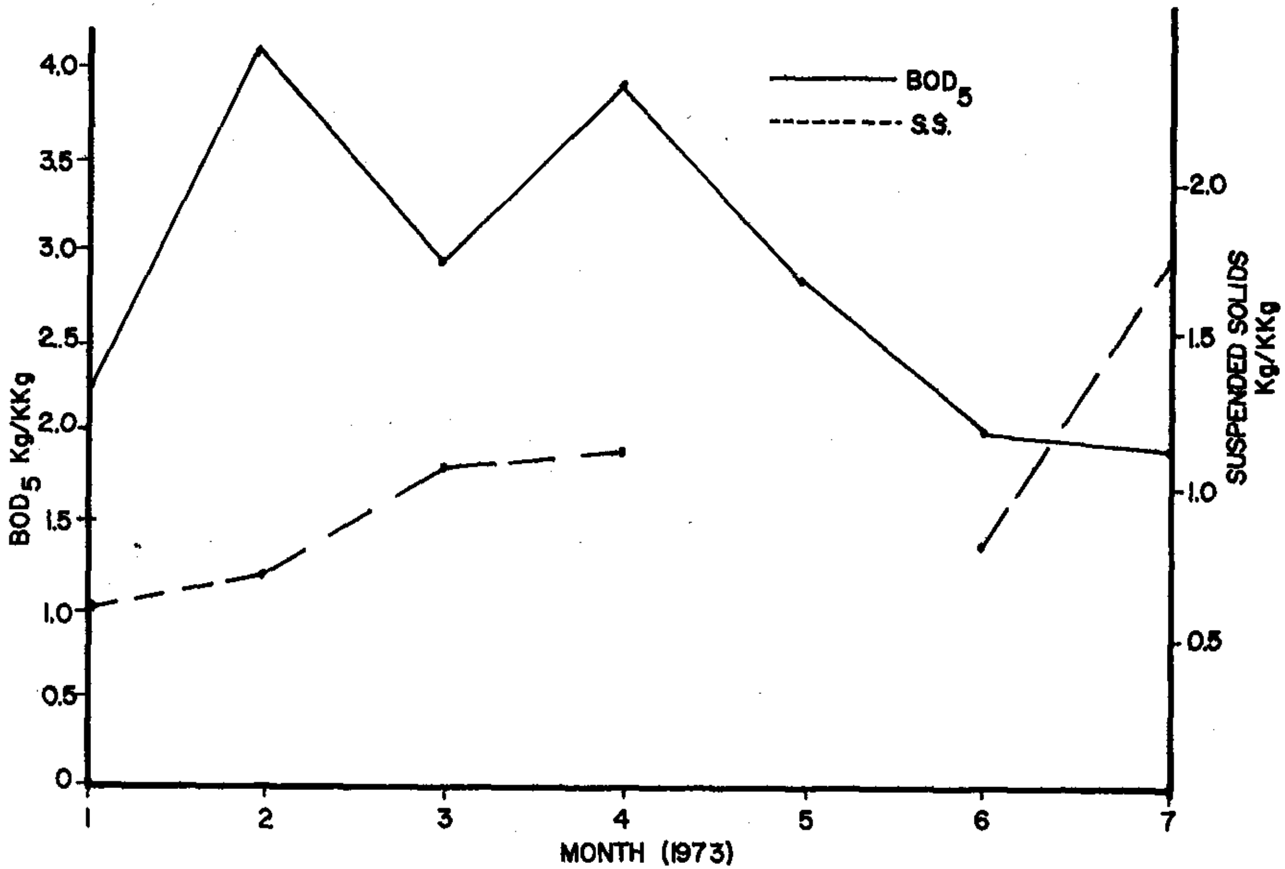


FIGURE 70 VARIATION IN BOD AND SUSPENDED SOLIDS FROM SECONDARY TREATMENT IN PLANT NO. 14

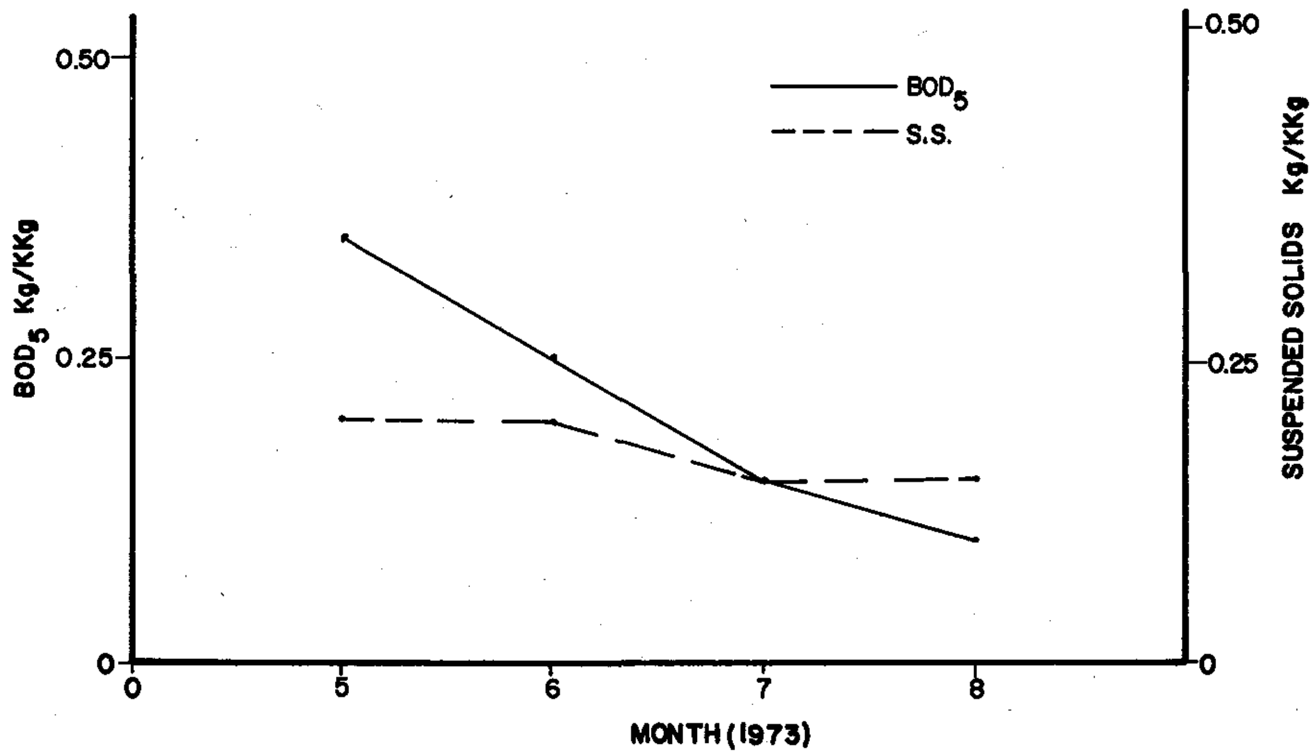


FIGURE 71 VARIATION IN BOD AND SUSPENDED SOLIDS FROM SECONDARY TREATMENT IN PLANT NO 16

Spray Irrigation - Three plants presently dispose of all or part of their wastes by spray irrigation. Plants 3 and 15 presently dispose of all waste water by spray irrigation. Both plants have holding lagoons that hold the waste for approximately five months during the winter when the spray fields are frozen. Plant 5 presently disposes of a major portion of its waste by spray irrigation and is moving toward total disposal by this method. Two of the three plants are located in areas of relatively high rainfall and found it necessary to install underdrain systems to maintain a low water table and drain off excess water. The third plant is located in a relatively low rainfall area; therefore, an underground drainage system was found to be unnecessary. Because of the lack of rainfall, this plant achieves essentially zero discharge.

If land is available, if proper soil conditions are present, and if the system is designed and operated properly, spray irrigation can be expected to provide BOD reductions of up to 99 percent. Inadequate land space, unsuitable soil conditions, and high costs will prevent spray irrigation from being feasible at many insulation board mills.

Evaporation - Evaporation of waste water can be considered either as an end of line treatment technology or an inplant method of water recycle. As an insulation board white water system is closed through this recycle, the concentration of soluble and suspended organics increase. Suspended solids can be controlled by sedimentation or filtration; however, dissolved solids are considerably more difficult to control.

A potential method for control of dissolved solids from the white water systems of an insulation board mill is evaporation. Evaporation would possibly be economical only for those plants that steam a major portion of their furnish, i.e., subcategory II. At the present time two hardboard plants in the U. S. and one in Sweden utilize evaporation for treatment of a major portion of their waste water load. The two plants in the U. S. utilize the explosion process which results in considerable quantities of dissolved organics. Counter-current washers are used to remove a major portion of the organics from the fiber prior to dilution and mat formation. The waste is discharged to a clarifier and the overflow goes to a multi-effect evaporator. The concentrated organic stream from the evaporator is either sold as cattle feed or incinerated. The condensate is either reused as process water or discharged as a waste water stream.

The Skinnskattenbergs Bruk plant in Sweden presently evaporates all of its waste water discharge from the white water system. A five-effect evaporator is utilized to evaporate 30 cu m (7,900 gal) per hour. Blowdown from the white water system has a total solids concentration of 2.7 to 3.2 percent and is evaporated to approximately 30 percent solids. The concentrated material is then burned along with sander dust in a boiler.

At the present time, no insulation board plant is known to utilize evaporation for waste water treatment although at least one plant in the U. S. is considering this type of system. The major question concerning the use of evaporation in the insulation board industry is economics. The cost of evaporation is directly related to the quantity of water to be evaporated which is in turn related to the concentration of dissolved organics in the white water system as discussed previously. Evaporation cannot be recommended as a viable treatment alternative for every insulation board plant as a detailed feasibility study and cost estimate should be conducted for each plant to determine its applicability.

Selection of Control and Treatment Technology for Model Plants

In Section V, model plants were developed for each of the insultion board subcategories. The subcategories and definition of waste water flow and composition are summarized as follows:

Subcategory	Liters/kkg	Flow cu m/day	BOD kg/kkg	SS kg/kkg
I	12,500	3400	12.5	10
II	12,500	3400	37.5	10

Each of the model plants is assumed already to have a primary clarifier in use because all insulation board plants either have primary clarification or the equivalent.

Except where noted the following treatment alternatives are applicable to both insulation board subcategories:

Alternative A - Alternative A assumes no additional treatment and control technology

Alternative B - Figure 72 shows a schematic diagram of Alternative B. This alternative consists of adding an aerated lagoon followed by a small settling lagoon to Alternative A above. The detention time of the aerated lagoon was 19 days based on the following formula:

$$\frac{Xo}{X} = 1 + KT$$

Where: X0 = influent BOD concentration, (mg/l)

X = effluent BOD concentration, (mg/l)

T = detention time in days,

K = constant which is dependent on the characteristics of a particular waste and temperature.

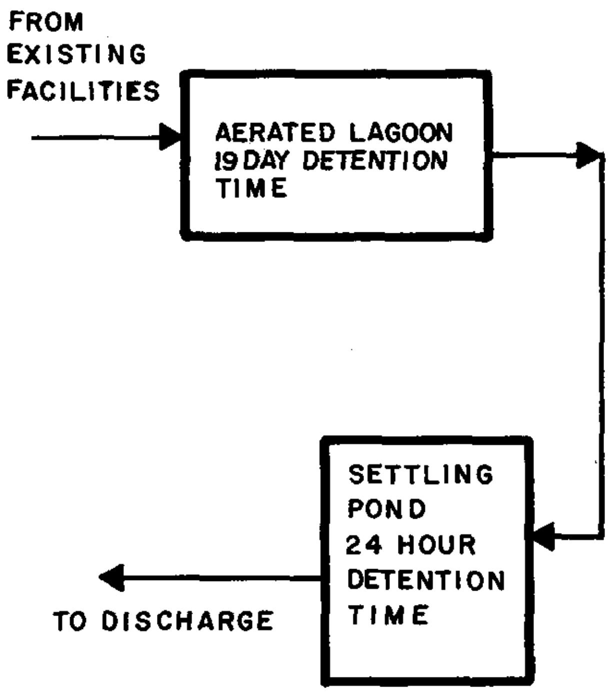


FIGURE 72 SCHEMATIC OF ALTERNATIVE B FOR INSULATION BOARD

A treatment efficiency of 85 percent is assumed using a highly conservative K = 0.3 at 20 C. The settling pond is assumed to have a detention time of 24 hours. The only variation between the design of the systems for the model plants is the quantity of aeration which is assumed to equal 1.5 times the BOD load per day. Sludge that settles in the settling pond is assumed to be removed yearly and disposed of by landfill. A total BOD reduction and suspended solids reduction of 85 and 70 percent, respectively, are assumed across both the aerated lagoon and settling pond. Reduction of suspended solids is based on an assumed effluent suspended solids concentration of 250 mg/l.

Alternative C-1 - Figure 73 shows a schematic diagram of Alternative C-1. This treatment alternative consists of the addition of an activated sludge system to the waste water stream. The following design assumptions were made:

Treatment process - complete mixed activated sludge

Mixed liquor suspended solids - 2,500 mg/l

BOD loading rate - 0.2 kg BOD/kg MLSS

Secondary clarifier loading rate - 20,000 l/sq m/day

Aeration requirements - 1.5 kg O_2/kg BOD/day

Because of the nutrient deficiency of the waste, nutrients in the form of anhydrous ammonia and phosphoric acid are added to the ratio of BOD: nitrogen: phosphorus of 100:2:2. Provisions are also made for pH adjustment as required.

Excess biological sludge is wasted to the sludge thickener. The activated sludge is wasted at a concentration of 0.8 percent solids and the sludge from the primary clarifier is wasted at a solids concentration of 3.0 percent. Sludge is pumped to a gravity thickener where the solids are concentrated to a solids concentration of 5.0 percent. The hydraulic loading rate on the sludge thickener is assumed to be 4000 l/sq m/day (100 gal/sq ft/day). Underflow from the sludge thickener is dewatered on a pair of vacuum filters. The dewatered sludge is hauled to landfill for final disposal. Supernatant from the sludge thickener and filtrate from the vacuum filters is returned to the primary clarifier.

The overall BOD removal efficiency is assumed to be 90 percent and the suspended solids removal to be approximately 70 percent. Reduction of suspended solids is based on an assumed effluent suspended solids of 250 mg/l.

Alternative C-2 - Figure 74 shows a schematic diagram of Alternative C-2. Alternative C-2 consists of the addition of an aerated lagoon which contains a quiescent area. The aerated lagoon is assumed to have a detention time of eight days and will provide an additional 70 percent BOD reduction to the effluent of

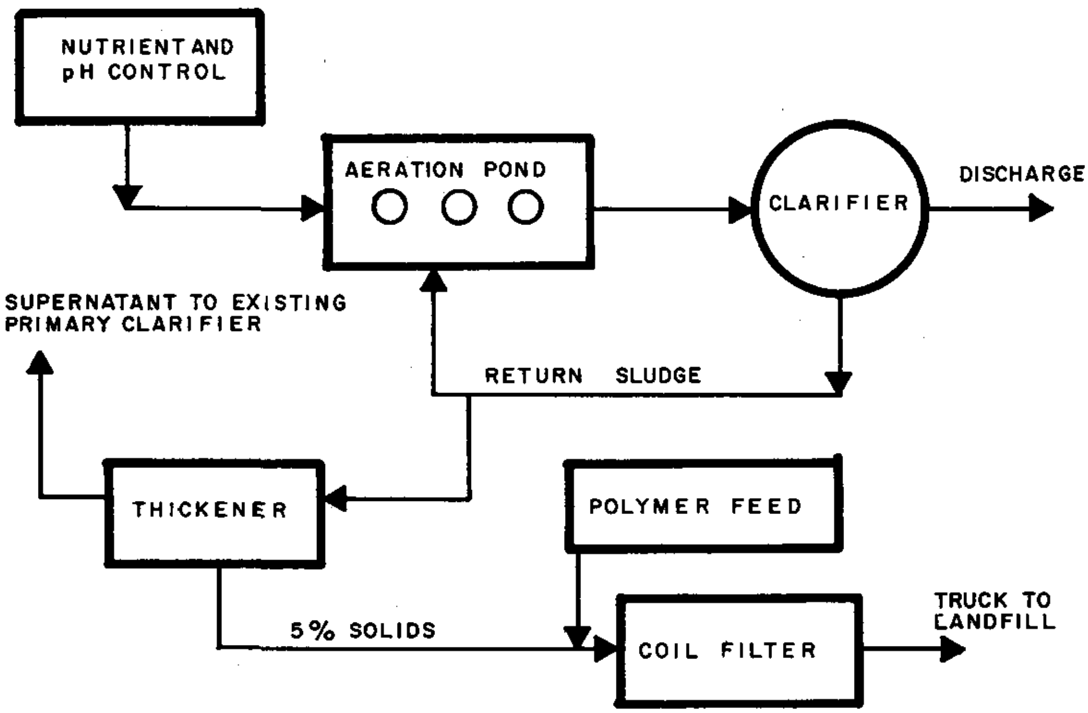


FIGURE 73 SCHEMATIC OF ALTERNATIVES C1 AND D1 FOR INSULATION BOARD

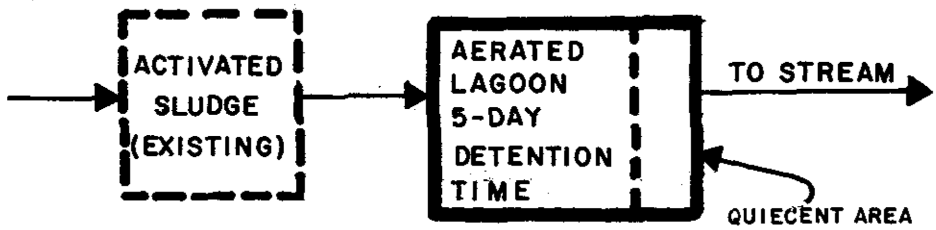


FIGURE 74 SCHEMATIC OF ALTERNATIVE C2 FOR INSULATION BOARD

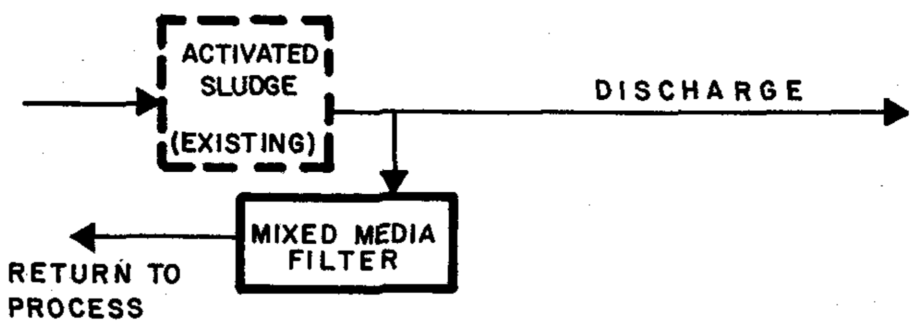


FIGURE 75 SCHEMATIC OF ALTERNATIVE D2 FOR INSULATION BOARD

the activated sludge system. No increase in suspended solids removal is assumed. The overall BOD reduction for Alternative C-2 is 97 percent and suspended solids reduction remains at approximately 70 percent.

Alternative D-1 - Alternative D-1 consists of the addition of the activated sludge system of Alternative C-1 to Alternative A.

Alternative D-2 - Figure 75 shows a schematic diagram of Alternative D-2. Alternative D-2 consists of the addition of mixed media filtration to the activated sludge process of Alternative D-1. A surface loading rate of 160 l/sq m/min (4.0 gal/sq ft/min) was assumed for the loading rate of the mixed media filter. The filter is designed to handle 100 percent of the plant effluent of 3400 cu m/day (0.9 mgd). The reason for the addition of a filter to the activated sludge process is to obtain a water quality sufficient for reuse inplant. Recycle after biological treatment is an unproven method of water reuse; however, industry representatives feel that it may be possible. At least one plant (No. 16) has experimented with water reuse after biological treatment with good results. The long term effects and the percent of recycle has not yet been determined. Alternative D-2 assumes 70 percent recycle which results in an overall BOD and suspended solids reduction of 97 and 91 percent, respectively.

Alternative E - Figure 76 shows a schematic diagram of Alternative E. This alternative can only be utilized by insulation board mills in subcategory II because they steam their furnish. Plant 4 also cannot use this alternative because it uses groundwood for its raw material. Further limitations with this alternative include that the plant either produce only one product or, if the plant has multiple lines making different products, each line must have a separate water system.

Alternative E requires that the process water systems be split at the decker resulting in a white water system for the fiber preparation system and a white water system for the machine forming system. It also requires the installation of a multiple effect evaporation system to handle blowdown from the fiber preparation white water system. The condensate from the evaporator will be used as partial makeup for the machine white water system after pH adjustment.

The evaporator will concentrate the waste to approximately 30 percent consistency. The concentrated material is then utilized as auxiliary fuel for producing steam. Additional fuel is required because of the high moisture content of the concentrate. Blowdown from the machine white water system goes to an activated sludge process using design parameters as previously described. Other assumptions are listed below.

1. Machine white water is used to wash the stock on the decker.

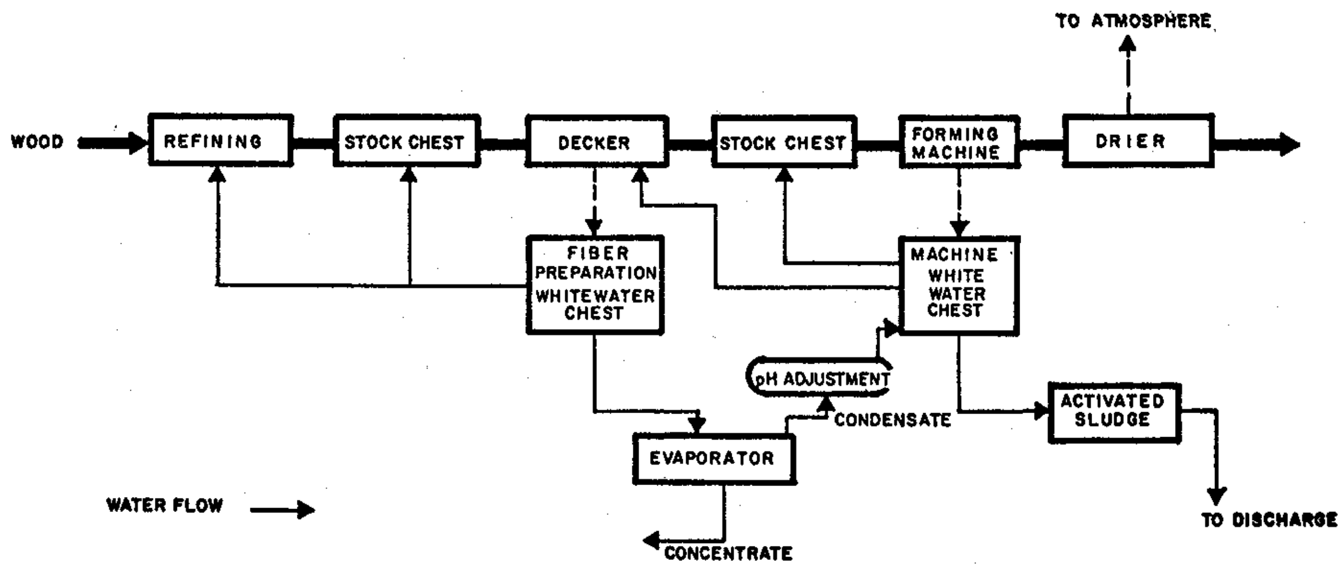


FIGURE 76 SCHEMATIC OF ALTERNATIVE E FOR INSULATION BOARD

2. Blowdown from the fiber preparation white water system has a dissolved solids concentration of 1.0 percent and a flow of between 950 cu m/day (0.25 mgd) 1200 cu m/day (0.31 mgd) for subcategory II.

3. Blowdown from the machine white water system has dissolved solids concentration of 0.5 percent and a flow of between 830 cu m/day (0.22 mgd) and 1,000 cu m/day (0.27 mgd) for subcategory II.

4. Stock leaving the decker into the machine white water system has water containing a dissolved solids concentration of 0.75 percent.

5. BOD/DS = 0.6

6. Overall efficiency of the treatment system is assumed to be 97 percent for BOD removal. Effluent suspended solids are assumed to be 250 mg/l.

Alternative F - Figure 77 shows a schematic diagram of Alternative F. This alternative involves spray irrigation of all waste water from the plant. Design of the spray irrigation system is limited by hydraulic capacity not organic load; therefore, the system is applicable to both subcategories.

Two separate spray irrigation systems are designed because of the temperature differences between northern climates and southern climates. For northern climates, a holding lagoon with five months waste water flow capacity is required because spray irrigation cannot be practiced during freezing conditions. Following the holding lagoon, waste water is pumped to a dosing pond with a 3 day irrigation capacity. Nutrients as required are added at this point. The spray irrigation system is designed on a hydraulic loading rate of 47,000 l/ha/day (5000 gal/ac/day). The system is also provided with an underdrain system.

The spray irrigation system for the southern climate is essentially the same as the one for the northern climate except that the five month holding lagoon is replaced by a 30-day holding lagoon lagoon. A 30-day holding for southern climates is required because at times heavy rains will exceed the hydraulic capacity of the irrigation field.

Spray irrigation can be used by only a limited number of plants because of lack of suitable land. If spray irrigation can be utilized at a plant, its treatment efficiency for BOD and suspended solids removal is predicted to be 99 percent.

A summary of the effluents produced by each of the treatment alternatives is presented in Table 63.

PARTICLEBOARD

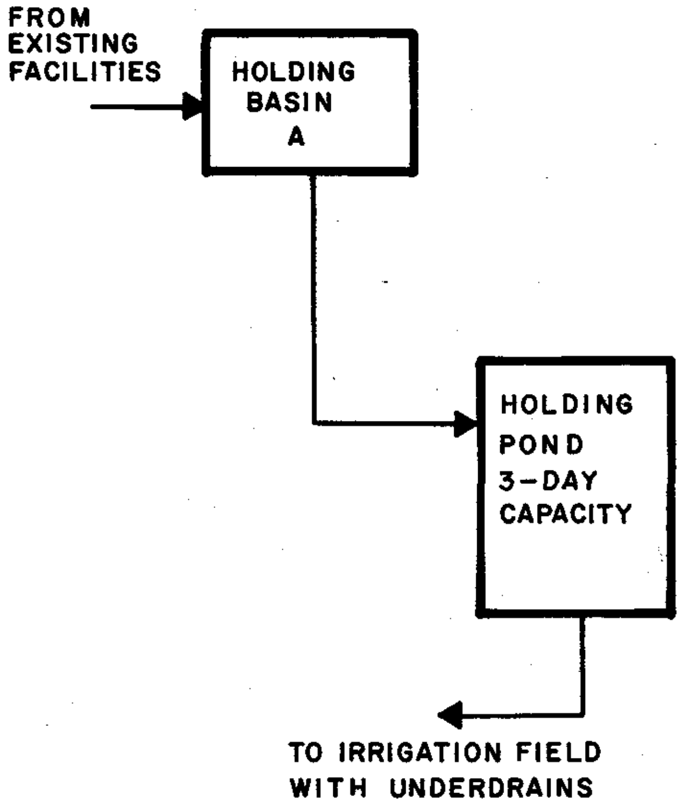


FIGURE 77 SCHEMATIC OF ALTERNATIVE F FOR INSULATION BOARD

TABLE 63

SUMMARY OF EFFLUENTS PRODUCED BY TREATMENT ALTERNATIVES FOR MODEL INSULATION BOARD PLANTS

	BOD Kg/KKg	SS Kg/KKg
SUBCATEGORY I		
Alternative		
A	12.5	10.0
B	1.3	3.1
C-1, D-1	1.3	3.1
C-2	0.4	3.1
D-2	0.4	0.9
F	0.2	0.1
SUBCATEGORY II		
Alternative		
A	30.0	10.0
B	3.0	3.1
C-1, D-1	3.0	3.1
C-2	0.9	3.1
D-2	0.9	0.9
F	0.3	0.1
E	0.9	0.8
SUBCATEGORY III		
Alternative		
A	37.5	10.0
B	3.8	3.1
C-1, D-1	3.8	3.1
C-2	1.1	3.1
D-2	1.1	0.9
F	0.4	0.1
E	1.1	2.0

The small volumes of water discharged, 11,000 l (3,000 gal) per day or less, from particleboard plants and the variation of waste water sources from plant to plant have limited development of waste treatment technology in the industry. In general, because of the small volumes of waste water generated, the major treatment processes are limited to waste retention ponds, settling ponds, or a combination of retention and settling ponds. The major waste water source in one mill may generate no discharge in another mill. Inplant modifications for the purpose of reducing, eliminating, or reusing waste water flow can greatly affect total waste water discharge in any mill; however, these are generally not applicable to all mills. Nevertheless, by the implementation of inplant modifications and end of line treatment technologies currently in use, the elimination of discharge from particleboard plants can be achieved.

Inplant Control Measures and Technology

Blender Cleaning - As previously mentioned, blender cleaning can be accomplished by either a wet or a dry method with the wet method requiring approximately 10 times more water than the typical dry method. There can be virtual elimination of waste water from the dry cleaning of blenders; however, it takes approximately four times longer to clean a blender by the dry method because of the manual labor required. Also, there are various types of blenders which cannot be cleaned by the dry method. Therefore, in some mills, it is economically as well as technically infeasible to clean a blender by the dry method. Because the volume of water utilized in a blender varies primarily with the rate of buildup on the interior of the blender, it is advantageous to reduce this rate of buildup by the use of a cooling jacket on the blender. The resins utilized by the particleboard industry are thermosetting and a reduction in temperature inside the blender will significantly reduce the amount of buildup and subsequently the frequency of washing required. However, as discussed in the description of the particleboard manufacturing process, there are certain types of blenders in use that are not adaptable to the use of cooling jackets, because of the nature of the blender's construction.

Cooling Water - Cooling water in some plants is transported in open ditches and can become contaminated with resin leaks and fugitive particles from the plant operation. When the cooling water becomes contaminated in this manner, the contaminants must be removed before discharge. One method of eliminating the pollution of cooling water is to transport it by closed conduits.

Wet Scrubbers - As mentioned previously, it is common practice in the industry to recycle a majority of the scrubber water through settling ponds to remove the dust and wood particles from the waste stream. This enables a high percentage of water to be recycled. Because there is extensive evaporation in a scrubber system, there is a need for continuous makeup water to be added. Various plants have reported the use of cooling water as well as waste waters for this makeup water purpose. The evaporation of waste waters in the scrubbers is one method of eliminating all discharges other than the blowdown from the scrubber.

End Of Line Technology

End of line treatment technology currently in use in the particleboard industry, as shown in Table 64, is limited essentially to:

1. Settling tanks
2. Containment lagoons
3. Septic tanks
4. Spray irrigation
5. Lagoons

In addition, at least one plant currently sprays its waste water on the incoming raw materials and another on the hog fuel for its boiler.

It is common practice for the several plants located in mill complexes to combine their waste waters into a common treatment system.

There are currently at least three particleboard plants that treat waste waters in lagoons prior to discharge. Lagoons rely on natural aeration or algae to provide oxygen to biologically decompose organic material in the waste water. Settleable solids undergo an anaerobic decomposition on the lagoon bottom. If properly designed, a treatment efficiency of from 80 to 85 percent BOD removal can be realized.

Settling tanks, which constitute the most common technology in use in the particleboard industry at this time, normally consist of baffled settling tanks approximately 2 by 3 m (6 by 10 ft) with a depth of 1 m (about 3 ft) or less. There is little available data on the efficiency of these settling tanks. They may discharge to municipal or other treatment systems, or directly to receiving waters. The sludge from these tanks is normally removed manually on an infrequent basis.

There is presently at least one plant (Plant 15) which uses a septic tank for waste water treatment. A septic tank is a settling tank in which the settled sludge is decomposed anaerobically. Septic tanks are followed by drain fields to allow the effluent to undergo aerobic stabilization and to percolate into the ground. Septic tanks are suitable for relatively low waste water flows which contain a sufficiently low solids content that soil percolation rates will not be adversely affected.

Spray irrigation was reported in response to questionnaires by only one plant (Plant 16) in the particleboard industry. The plant spray irrigates waste water in a neighboring forested area. This method of waste water treatment utilizes the soil microorganisms ability to decompose organic matter as well as the

TABLE 64

EXISTING PARTICLEBOARD WASTEWATER TREATMENT SYSTEMS

Plant No.	Type of Treatment
10, 22, 23	Settling Tank
1, 24	Settling Tank - Municipal Treatment
11, 25	Municipal Treatment
26	Settling Tank - Containment Lagoon
4, 6	Containment Lagoon
2	1) Settling Tank - spray on dirt roads 2) Containment
30	Settling Tank - Make-up for log pond evaporation
7	To discharging log pond
14, 18	Lagoon
15	Septic Tank
5	Spray or raw materials
16	Spray irrigate in woods
20	Lagoon - spray on sawdust landfill
8	Truck to landfill
3	Burn with hog fuel
9, 17, 31, 32	To mill complex's system
	Scrubbers
8, 10	Recycle
3	Screen and settling pond

soil's natural filtering ability to achieve waste water treatment and disposal. In most cases, with proper design and operation there is no threat of groundwater contamination. Related to this technology is the practice of one plant (Plant 2) of controlling the dust on its logging roads by wetting them with particleboard waste water.

Containment lagoons are is use in numerous industrial facilities in the timber products industry. These systems, reported in use by a small number of particleboard plants, utilize natural evaporation as well as seepage into the soil to dispose of waste water. The seepage into the ground water of undesirable substances is a possibility, and this effect must be considered before construction.

A type of treatment, similar to containment lagoons, is spray evaporation. The primary difference is that a spray mechanism of some type must be installed. The waste water is concentrated by evaporating most of the water by increasing the surface area exposed to the ambient air by use of spray nozzles. The sludge which accumulates on the bottom is usually disposed of in a landfill.

At least one plant (Plant 5) sprays its entire waste water discharge on the incoming raw material. The system consists first of settling ponds which remove settleable and floatable materials. The spray nozzles are activated by automatic switching devices and, in order to maintain a uniform moisture content on the incoming raw materials, it is sometimes necessary to supplement the waste water flow with cooling water. Initial work with this system has shown that the moisture content of the incoming raw material is increased by six to ten percent. Although this could theoretically create problems in the subsequent inplant processes, none have been reported to date. For example, refining has not been impaired; on the contrary, refining has been found to improve with the higher moisture content in the raw materials. Also, there has been no significant increase during the first eight months of operation of the fuel drying costs despite the increase in the moisture content. Finally, no degradation of the final product or incompatibility of the system has been observed because of the waste material present in the raw material.

There are two other systems currently in use by particleboard plants. These consist of 1) spraying of waste water on the hog fuel, and 2) trucking waste to landfills. Spraying waste water on hog fuel appears to be a viable alternative if the volumes of waste are low and a hog fuel boiler is available. This system may raise the moisture content of the raw fuel and result in more energy being required to run the boilers. The small number of plants that truck waste to land fills do so because inplant equipment and process variables such as type of resin, tack, and particle size allow a reduction of waste water flow to less than 400 l (100 gal) per day.

Treatment Technology For the Particleboard Plant

The treatment technologies considered to be applicable to the particleboard plant discharging 11,000 l (3,000 gal) per day of waste water as described in Section V are:

1. Discharge to municipal system
2. Discharge to a septic tank
3. Spray irrigation
4. Spray evaporation
5. Spraying of all waste water on incoming raw material
6. Spraying of waste water on hog fuel

Containment lagoons, rely heavily on percolation to dispose of waste water. Since the percolation characteristics of the terrain are a major factor, the use of containment lagoons is considered to be applicable only in certain cases and not on an industry-wide basis. Oxidation ponds are not considered applicable treatment technology because 1) they require large land areas, 2) they are subject to odor problems, and 3) they do not provide for no discharge of pollutants from the process waters as do other more feasible methods. Trucking to landfill may be a viable alternative for plants discharging small quantities of water.

Description of Model Systems

Models of the treatment and control technology considered to be applicable have been developed as follows:

Alternative A - Alternative A consists of no treatment of waste waters and, therefore, no reduction of pollutants.

Alternative B - Alternative B consists of a septic tank utilizing prior screening as shown in Figure 78. The screening consists of a coarse screen and a fine screen in series. The coarse screen has 3 mesh (0.25 in) openings, and the fine screen is a 20 mesh screen (0.7 mm). These are flat screens and are cleaned manually on a daily basis.

Alternative C - Spray irrigation systems, as shown in Figure 78, are designed for two climatic areas, northern and southern. The former area has winter conditions which produce snow and icing. The second is for all other areas. The first system consists of a holding pond of five months capacity, a storage tank with a three day capacity, and a properly designed spray irrigation field. The five month capacity of the holding pond provides for containment of the plant's effluent during the winter months when spray irrigation is not feasible. The three day storage tank is used as a sump. The second type of system also has a three day storage tank and a spray irrigation field. However, the holding pond is of a 30 day capacity to provide for adequate storage during periods of heavy rainfall when spray irrigation is not feasible. The hydraulic loading rate for the irrigation fields

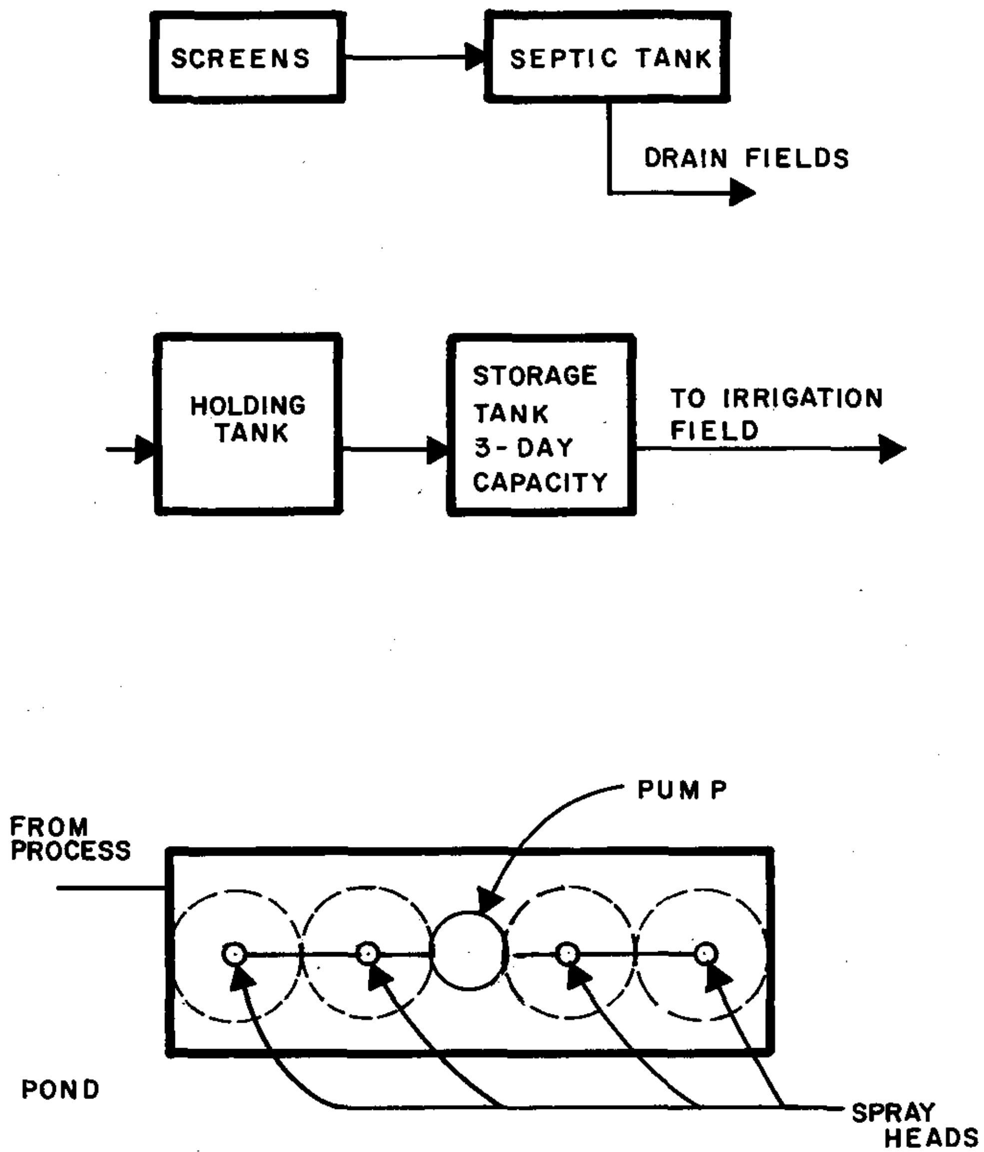


FIGURE 78 SCHEMATICS OF ALTERNATIVES B, C, AND D FOR PARTICLE BOARD

is 47,000 l/ha/day (5000 gal/ac/day). Though spray irrigation systems depend somewhat on climatical and soil percolation factors this type of system can be used in a wide variety of areas because the treatment of the waste water (removal of pollutants) occurs primarily because of biological actions in the soil and the filtration by the soil of the waste water.

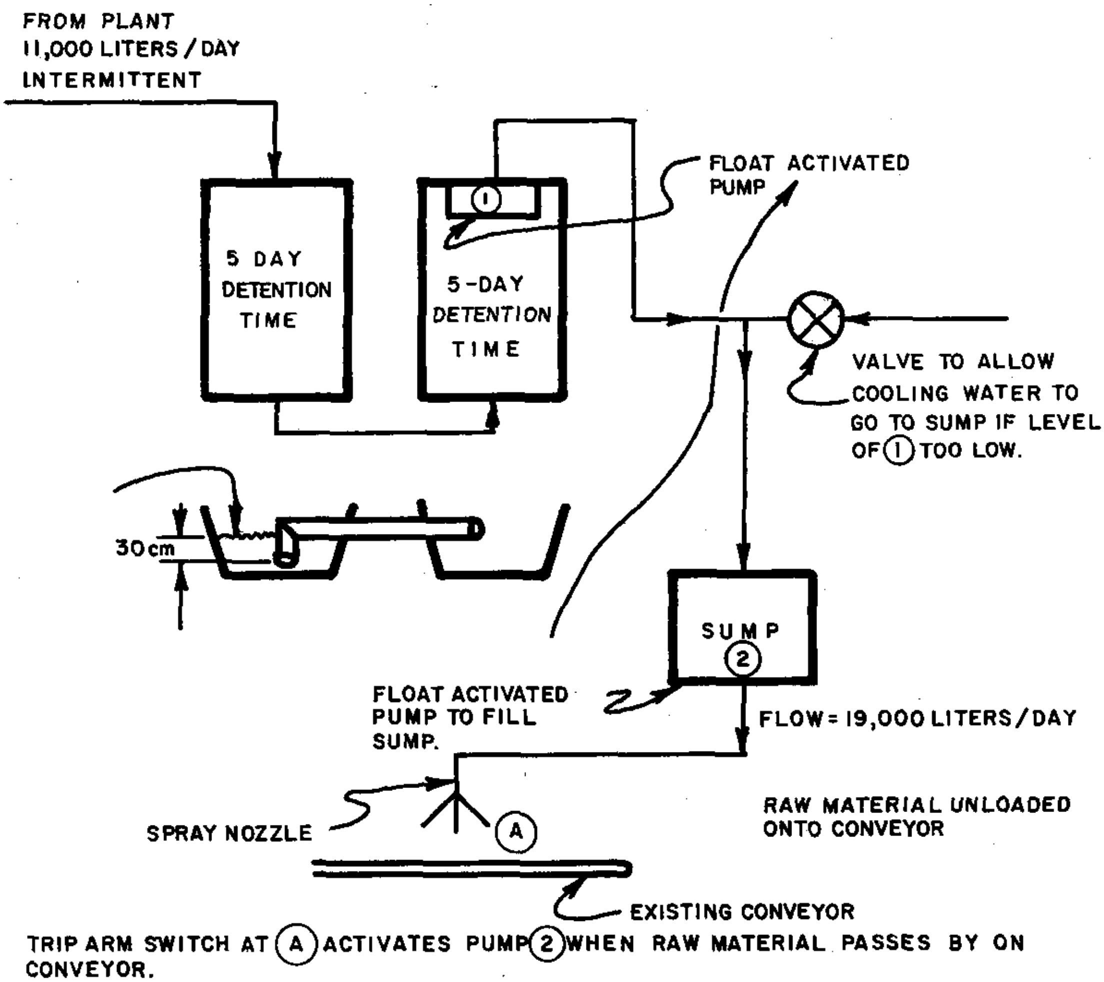
Alternative D - Alternative D consists of spray evaporation of all waste water from the particleboard plant as shown in Figure 78. Systems were designed for the four climatical areas where particleboard plants are located. These are the northwest (Seattle area), the New England area, the southeast (Mississippi) area, and north central (Minnesota) area. These areas were chosen on the basis of rainfall and climate to represent evaporation rates to be found in the majority of the particleboard industry. All systems consist of lined lagoons with spray units installed.

Spray units consist of a number of spray nozzles connected to a central 75 hp (56 kw) pump. All systems are designed such that the spray units need to be operated only 5 months per year; however, during the 5 month period, in some areas it is necessary to operate the spray unit on a continuous basis and in others it is necessary only to operate the spray unit intermittently. The design criteria including the size of the lagoons and period of daily operation is as follows:

Climatic Area	Length m	Width m	Depth m	Operating Time Days
Northwest	85	21	3	24
New England	62	16	3	12
Southeast	59	15	3	11
North Central	65	16	3	13

It should be noted, as indicated above, that all spray ponds are rectangular in shape with a length to width ration of 4:1. This design was necessary for two reasons: 1) the size and shape of the spray units, and 2) the long axis should be perpendicular to the prevailing wind of the area so that the maximum evaporation can occur by preventing waste water spray from one nozzle from being flown into the area of influence of another spray nozzle, as this would reduce the evaporation rate and efficiency of the unit.

Alternative E - Alternative E requires two ponds in series, each of five day detention time, from which water is pumped to a sump. The water from the sump is applied to the raw materials by spray nozzles located over an existing conveying device which takes the material from the unloading area to the storage area as shown in Figure 79. As the raw material passes under the spray nozzles, a trip-arm switch activates the pump from the sump and the water is



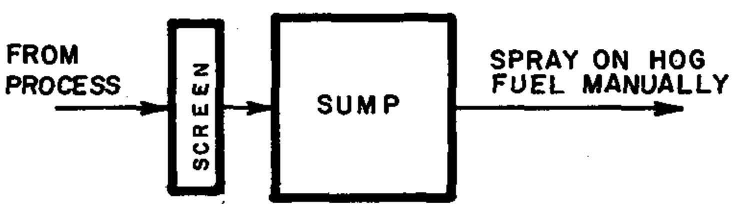


FIGURE 79 SCHEMATICS OF ALTERNATIVES E AND F FOR PARTICLE BOARD

applied to the raw materials. Between the settling ponds and the sump, a valve is required too allow cooling water to enter the sump and be applied to the raw materials. This provides for adequate water supply to be placed on the incoming raw material so that the raw material can have a uniform moisture content, which is critical for production purposes. There is a float activated valve in the second settling pond which allows for waste water to be pumped from the pond to the sump if the level of the pond is above a minimum depth. There is also a float in the sump to provide for pumping from the settling ponds or cooling water to fill the sump when the level gets too low. The amount of water sprayed on the incoming raw material is approximately 19,000 l (5,000 gal) per day. This is a rate of a little over 67 l per metric ton (16 gal per ton) of raw material. The plant currently utilizing this system has an application rate over three times greater. (200 liters per metric ton)

Alternative F - Alternative F is a system for spraying all the waste water on hog fuel as shown in Figure 79. It consists of screens, sump, a pump, and a spray nozzle. The screens are of the same design as described for Alternative B. The waste water, after screening, passes to a 19,000 l (5,000 gal) sump and is then sprayed onto the hog fuel either while the hog fuel is in storage or is being conveyed to the boiler.

FINISHING

Finishing operations, involving the use of water base, liquid finishing materials, and overlaying operations involving water soluble adhesives, require equipment washdown operations which result in the production of an intermittent, concentrated, waste water flow. Volumes of waste water generated from this source vary considerably from plant to plant, but will usually fall in the range of 75 lpd to 1,100 lpd (20 gpd to 300 gpd).

Inplant Control Measures

As discussed in Section V, the cleanup techniques practiced at any particular plant will significantly affect the volume of waste water generated. For instance, the volume of washwater required for a direct roll coater used in applying a waterbase material, in most cases, could be reduced from as much as 132 l (35 gal) per wash to as little as 19 l (five gal) per wash. This reduction can be accomplished by the use of only a small volume of water initially and recycling the same water through the applicator several times before rinsing with fresh water. It may be possible to reuse this washwater for several cleanup operations if the type of finishing material is not varied. The use of high pressure nozzles to wash paint drums can reduce the total waste water production also. However, the best inplant control measures simply consist of the implementation of conservative water use practices.

End Of Line Treatment Technology

Current control and treatment technology for waste water generated from the use of water base liquid finishing materials and water soluble adhesives used in overlaying operations consists of the following:

1. Containment in drums or holding tanks followed by landfill disposal.
2. Land spread disposal.
3. Containment in shallow lagoons with evaporation and infiltration.
4. Containment in drums or holding tanks with settling of solids followed by reuse of the supernate and landfill disposal of the solids.
5. Containment in holding tanks followed by dis charge into municipal sewers.

These alternatives have been discussed previously for control and treatment of glue washwater from fabricating operations.

Because of the potential soil clogging effect, as discussed for glue wash waters in fabricating operations, containment pond design should be based on zero infiltration with provision for induced evaporation in areas where precipitation exceeds evaporation. The size requirements for such ponds for five selected regions are presented in Table 60.

Another presently practiced method of disposal for plants generating these smaller volumes of washwater is landspreading. Since no studies have been conducted on the biodegradability of these materials, no conclusions can be drawn as to the extent of degradation that is accomplished by soil bacteria in this disposal method.

Discharge of these washwaters into municipal sewers is also a commonly practiced method of disposal. However, because of the great diversity in constituents of the materials, and in the resulting waste waters, the effects of such a practice can only be considered on an individual plant basis. Some of these materials may contain various additives which serve as stabilizing agents to prevent biological contamination during the shelf life of the material. Such additives could be detrimental to the biological processes of a municipal treatment facility. In most cases, however, either the constituents of the waste waters may be biodegradable or the volumes small enough, or both, such that the waste water stream would be compatible with a municipal treatment facility. Pigments in these materials often contain heavy metals such as lead and cadmium which might pass through a municipal treatment system unremoved from the treated effluent.

Recommended Treatment Alternatives

On the basis of the above discussion, the following treatment alternatives are recognized:

Alternative A - No control or treatment.
Alternative B - Spray evaporation.
Alternative C - Incineration.
Alternative D - Landspreading.
Alternative F - Discharge to municipal sewer.

The above alternatives correspond to those selected for Model 1 for fabricating with the exception that screening of the waste water is not required. Also, Alternative E for fabricating operations, recycle of washwater, is not a practicable technology for finishing materials because of variations in finishing materials. Thus, each applicator may be applying a different material and these materials should not be mixed. Reference should be made to the recommended control and treatment technologies for fabrication for design details for the above alternatives.

SECTION VIII

COST, ENERGY, AND NON-WATER QUALITY ASPECTS

This section presents an evaluation of the costs, energy requirements, and non-water quality aspects associated with the treatment and control alternatives developed in Section VII.

In absence of complete cost information for individual processes, the cost figures developed herein are based on reliable actual cost figures reported for various installations coupled with engineering estimates. Adequate engineering estimates for a single installation must necessarily involve consideration of a multitude of factors. An estimate completely applicable to all members of an entire industry subcategory is obviously impossible. For instance, it must be realized that land costs vary widely. While some lands associated with remote timber processing operations may sell for under a hundred dollars per hectare, land at an urban complex may be unavailable at any price. Construction cost, in terms of both labor cost and materials cost, is another element that is highly variable. Therefore, the costs presented herein are intended to serve as a guide only.

The engineering estimates for all cost analyses in this section employed the following assumptions:

1. Excavation cost = $1.96/cu m ($1.50/cu yd).
2. Road cost = $3.00/sq m ($2.50 sq yd).
3. Contract labor = $10.00/hr.
4. Power costs = 2.3¢/kw hr.
5. All costs reported in August 1971 dollars.
6. Trucking haul cost = $20.00/trip.
7. Landfill fee = $37.85/cu m ($0.143/gal) for sludge.
8. Landfill fee = $2.50/ton).
9. Tank truck assumed to be of 5.68 cu m (1500 gal) capacity.
10. Annual interest rate for capital cost = 8 percent.
11. Salvage value of zero over 20 years for physical facilities and equipment.
12. Depreciation is straight line.

13. Total yearly cost = (investment cost/2) (0.08) + (investment cost) (0.05) + yearly operating cost.

IMPOUNDMENTS AND ESTUARINE STORAGE AND TRANSPORTATION

Cost and Reduction Benefits of Alternative Treatment and Control Technologies

No control and treatment technology was formulated and, therefore, no costs are calculated.

Related Energy Requirements of Alternative Treatment and Control Technologies

The transportation of logs via water is practiced extensively in the Northwest. The logs are lowered or dumped into the water and made up into rafts. These rafts may contain four or five thousand cu m of logs. The log rafts are towed to the processing mill by a tugboat. There are several of these raft formation sites on the estuaries of Washington State alone, each accepting one or two train loads of logs each day. The energy required to transport the logs to the mill, a distance of a 160 km (100 miles) or more, via rail or truck would be significantly greater than the energy required to transport the logs on the water. In addition, the energy required to construct the new railways and highways necessary to accommodate the higher traffic volumes would be substantial.

The energy requirements for land decking of logs in relation to water storage of logs were investigated by Schaumberg. The results of this study are discussed in detail later in this section but, in brief, the study showed that the energy cost to land deck the logs only 0.8 km (0.5 mi) from the mill was far greater than water storage at the mill site. Based on this study, it could be concluded that the land transportation of logs over 160 km (100 miles) with dry decking at the mill would require considerably more energy than water transportation and storage.

Non-Water Quality Aspects of Alternative Treatment and Control Technologies

The non-water quality aspects of impoundment and estuarine storage and transportation are primarily associated with the alternative of removing the logs from the water. The increased production of both solid wastes and air pollutants if land decking were used will be discussed, but if rail or truck transportation all the way to the mill were used, there are other factors to be considered.

Most mills that process the water transported logs are located on the water. In many cases, a town or city has developed around the mill to the extent that the mill does not have room to expand. If a rail or truck terminal were to be located at the mill site, the cost of purchasing the adjacent property might be prohibitive. In addition, the traffic generated by this change would have an adverse social impact.

Several studies have been performed on the loss of bark from river and estuarine storage and transportation. These studies, as discussed in Section V of this document, relate primarily to water quality aspects in bark loss. Floating bark is aesthetically displeasing and so attempts to prevent bark from entering the water for water quality reasons will also make the log rafting area more aesthetically pleasing. Easy let-down devices have been observed to markedly reduce the amount of bark lost from the logs during placement of the logs in the water. For this reason, easy let-down devices are appearing in the industry in more places.

WET STORAGE

The following discussion of the cost, energy, and non-water quality aspects of treatment and control technologies applicable to the holding of raw materials in a wet environment is broken down into mill ponds, log ponds, and wet decking. The purpose of this breakdown is to demonstrate the range of technologies and the range of costs applicable to the various treatment and control schemes.

MILL PONDS

The effluents from mill ponds are considered to be derived from natural precipitation. All extraneous flows to the mill pond are considered to be routed around the mill. Various treatment schemes are available for treatment of this effluent discharge. Six alternative schemes were selected in Section VII as being applicable engineering alternatives. These alternatives provide for various levels of treatment of the waste stream from a mill pond.

Cost and Reduction Benefits of Alternative Treatment and Control Technologies

Alternative A - It is estimated that 31.5 million l (8.31 million gal) of waste water emanate from the one hectare (three acre) mill pond each year, or on the average 86,173 lpd (22,767 gal per day). The suspended solids load for the same waste, based on a concentration of 50 mg/l, is 4.3 kilograms per day (9.5 pounds per day).

This alternative requires reasonable process water use and control in order to achieve volume limitations related to precipitation and evaporation rates. The control of the discharge of debris also any require production management procedures, as discussed in Section VII to control the generation of these materials. The physical layout and arrangement of the wet storage facility and the timber processing equipment also influence the possible discharge of debris.

Because of the variety of wet storage operations as they exist in the field, it is not possible to present absolute cost information. The costs of achieving the proposed limitations range between $0 and a maximum of $9,000.

Control of the discharge of floating materials can be achieved by such technologies as floating log booms, submerged weir discharge structures, or inverted discharge pipes, or screens.

Control of debris, diameter exceeding 2.54 cm (1.0 in), is usually achieved by installations minimizing activity near points of discharge or by settling action that takes place in the collection area of a wet deck recycle system.

Alternative B - The use of an equalization basin may be appropriate for treatment of an intermittent flow. In this case, the equalization basin is also used as a sedimentation basin. The costs of control and treatment in Alternative B are as follows:

Incremental Investment Costs	$29,200
Total Investment Cost	$29,200
Total Yearly Operating and Maintenance	$ 2,400
Total Yearly Cost	$ 5,000

An itemized cost breakdown for Alternative B is presented in Table 65.

The reduction benefits for Alternative B involves a COD reduction of 20 percent and a suspended solids reduction of 50 percent.

Alternative C1 - This alternative is the same as Alternative B. The costs and unit efficiency are the same.

Alternative C2 - This second oxidation pond is fed by a pump from the first pond and, consequently, is expected to be more effective because of the more constant feed rate.

The costs of control and treatment for Alternative C2 are as follows:

Incremental Investment Costs	$18,300
Total Investment Cost	$47,500
Total Yearly Operating and Maintenance	$ 3,100

TABLE 65 ITEMIZED COST SUMMARY OF ALTERNATIVE B FOR MILL PONDS

Investment Costs			
Items:	1.	Basin	$21,000
	2.	Pump	840
	3.	Effluent Weir	168
	4.	Engineering	2,200
	5.	Contingencies	2,420
	6.	Land (1.1 ha@ $2470/ha)	2,600
		Total costs	$29,228
Operating Costs			
	1.	Operation and maintenance	$ 2,263
	2.	Power Costs	101
		Total costs	$ 2,364
Total Yearly Cost for equalization-sedimentation basin			$ 5,000

Total Yearly Cost	$ 7,400

An itemized cost breakdown for the second oxidation pond is presented in Table 66.

The reduction benefits for Alternative C2 include a COD reduction of 60 percent and a suspended solids reduction of 20 percent and the incremental suspended solids reduction is 10 percent. A cost efficiency curve for Alternative C is presented in Figure 80.

Alternative D1 - This alternative is the same as Alternative B. The costs and efficiency are the same.

Alternative D2 - The addition of chemicals, the flocculation, and sedimentation of the resultant floc are all considered to be integral portions of Alternative D2.

The costs of control and treatment for Alternative D2 are as follows:

Incremental Investment Cost	$47,200
Total Investment Cost	$76,500
Total Yearly Operating and Maintenance	$43,400
Total Yearly Cost	$50,200

An itemized cost breakdown of chemical coagulation, flocculation, and sedimentation is presented in Table 67.

The reduction benefits for Alternative D2 include a COD reduction of 60 percent and a suspended solids reduction of 90 percent. The incremental reduction of Alternative D2 over D1 is 48 percent for COD and 45 percent for suspended solids. A cost efficiency curve for Alternative D is presented in Figure 81.

Alternative E1 - This alternative is the same as Alternative B1. The costs and efficiency are the same.

Alternative E2 - This alternative is the same as Alternative D2. and efficiency are the same.

Alternative E3 - The filtration of the effluent from Alternative E2 pressure sand filters will provide some additional COD and suspended solids removal.

The cost of control and treatment for Alternative E3 are as follows:

Incremental Investment Cost	$ 36,900
Total Investment Cost	$113,400

TABLE 66 ITEMIZED COST SUMMARY OF ALTERNATIVE C2 FOR MILL PONDS

Investment Cost for Second Oxidation Pond Items:		
1.	Weir	$ 168
2.	Pond	13,020
		$13,188
3.	Engineering 10%	1,318
4.	Contingencies 10%	1,450
5.	Land 0.94ha @ $2,470/ha	2,340
	Incremental Costs	$18,296
	Cost of Alternative C-1	29,228
	Total Costs	$47,524
Operating Cost for Second Oxidation Pond		
1.	Equipment Maintenance	$ 42
2.	Pond Maintenance	729
	Incremental Cost	$ 771
	Cost of Alternative C-1	2,364
	Total Cost	$ 3,135
Total Yearly Cost for Second Oxidation Pond		$ 2,418

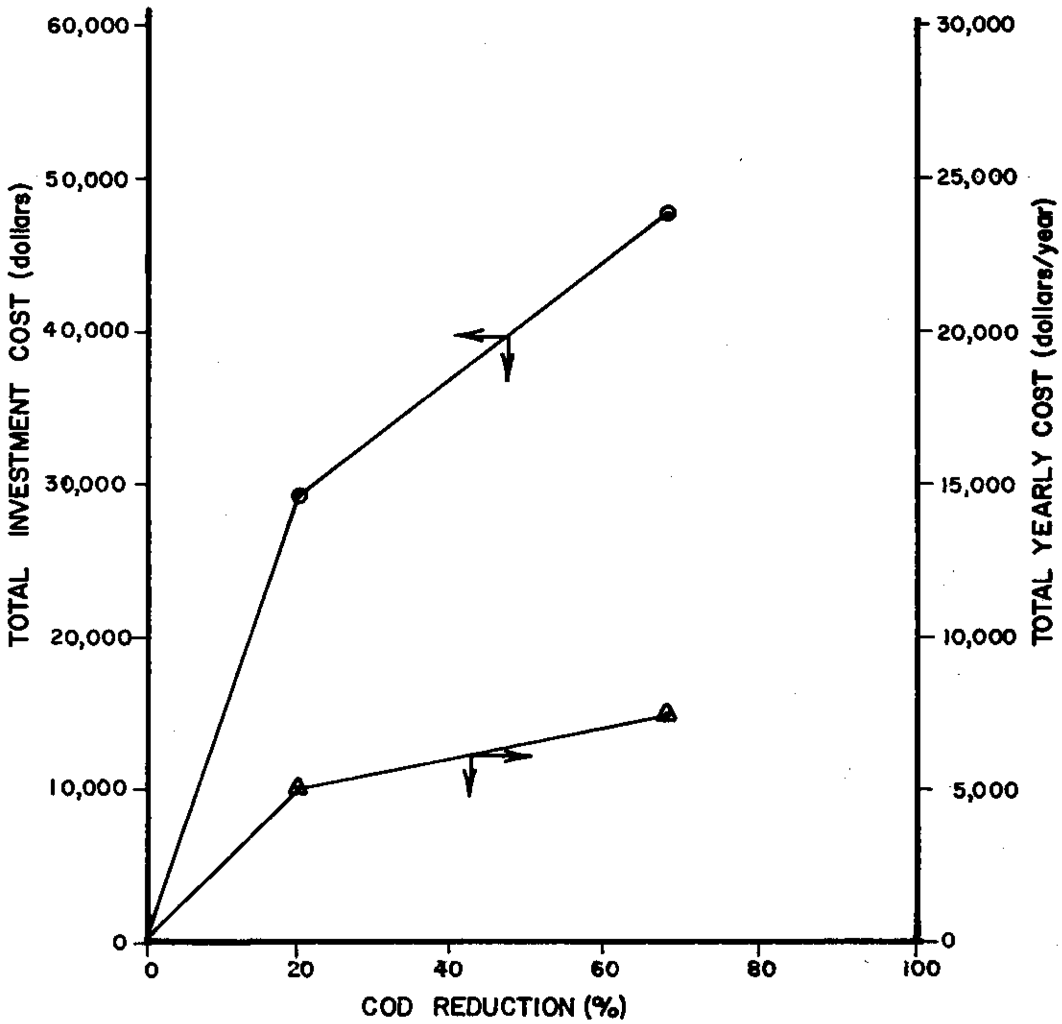


FIGURE 80 TOTAL INVESTMENT COST AND TOTAL YEARLY COST vs COD REDUCTION FOR ALTERNATIVE C

TABLE 67 ITEMIZED COST SUMMARY OF
ALTERNATIVE D2 FOR MILL PONDS
CHEMICAL COAGULATION, FLOCCULATION, AND SEDIMENTATION ONLY

INVESTMENT COST	
Mixing and chemical addition	$13,236
Flocculation	3,716
Sedimentation	17,402
Sludge disposal	4,261
	$38,615
Engineering 10%	$ 3,862
Contingencies 10%	4,248
Land .006 + .001 + .0014 + .1933 X $2470/ha	498
Incremental Costs	$47,223
Cost of Alternative D1	29,228
Total Costs	$76,451
OPERATING AND MAINTENANCE	
Flocculation	$ 84
Sedimentation	523
Chemicals and Mixing	38,847
Building	88
Sludge Disposal	1,166
Power	262
Incremental Cost	$40,970
Cost of Alternative D1	2,364
Total Costs	$43,334
Total Yearly cost for chemical coagulation-flocculation-sedimentation	$45,220

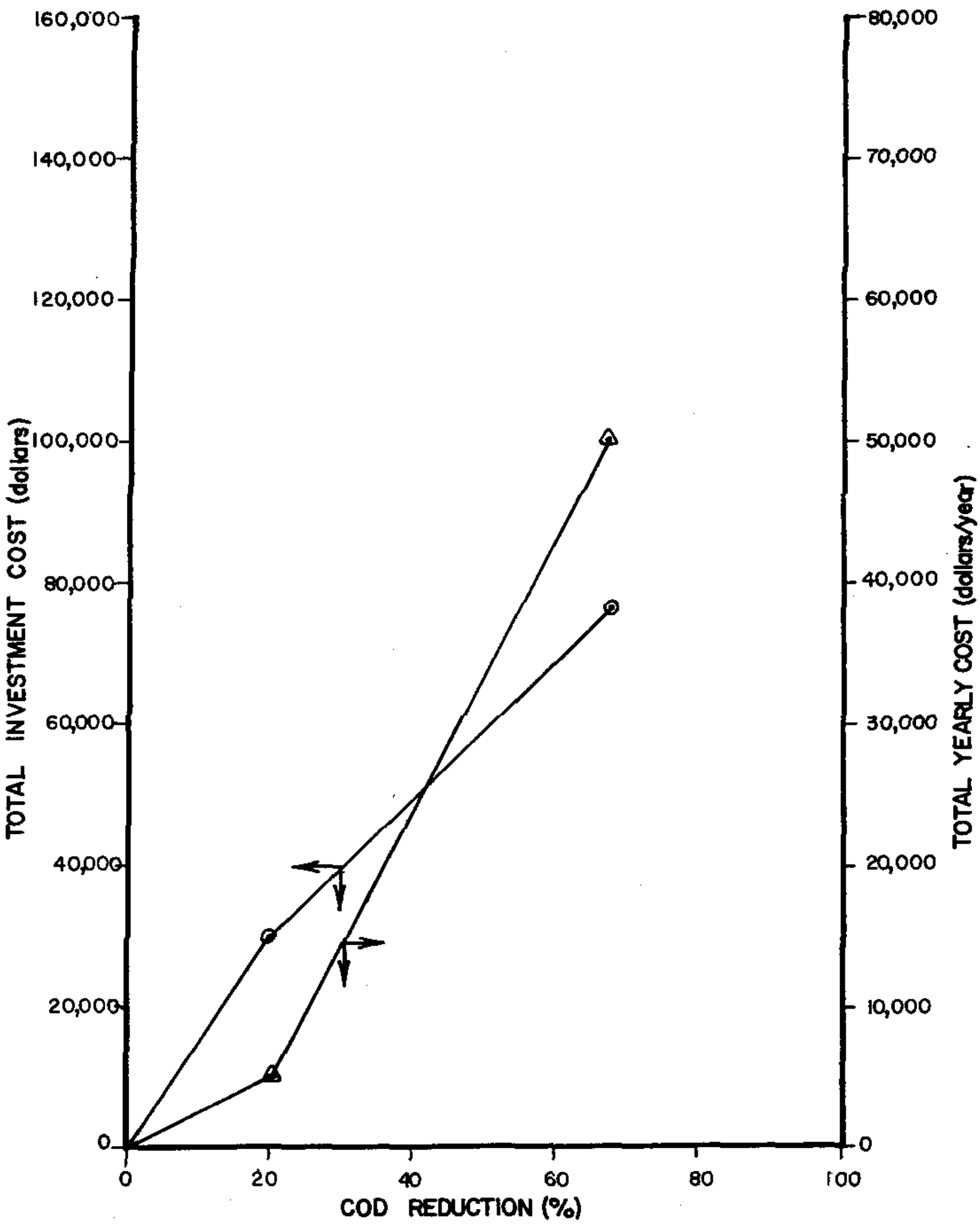


FIGURE 81 TOTAL INVESTMENT COST AND TOTAL YEARLY COST vs COD REDUCTION FOR ALTERNATIVE D

Total Yearly Operating and Maintenance	$ 47,400
Total Yearly Cost	$ 57,500

An itemized cost breakdown of the filtration operation is presented in Table 68.

The reduction benefits for Alternative E3 include a COD reduction of 20 percent and a suspended solids reduction of 90 percent. The incremental reduction of Alternative E3 over Alternative E2 is six percent for COD and 4.5 percent for suspended solids.

Alternative E4 - The use of activated carbon will reduce the organic fraction of this effluent, but the suspended solids level is not reduced.

The cost of control and treatment for Alternative E4 are as follows:

Incremental Investment Cost	$ 23,600
Total Investment Cost	$137,000
Total Yearly Operating and Maintenance	$ 59,400
Total Yearly Cost	$ 71,700

An itemized cost breakdown of the activated carbon process is presented in Table 69.

The reduction benefits for Alternative E4 include a COD reduction of 75 percent. The incremental reduction of Alternative E4 over Alternative E3 is 19.5 percent for COD and zero for suspended solids.

A cost efficiency curve for Alternative E is presented in Figure 82.

Alternative F5 - The spray evaporation process should achieve zero discharge in the most economical fashion.

The costs of control and treatment for Alternative F are as follows:

Incremental Investment Cost	$647,700
Total Investment Cost	$647,700
Total Yearly Operating and Maintenance	$ 69,800
Total Yearly Cost	$128,100

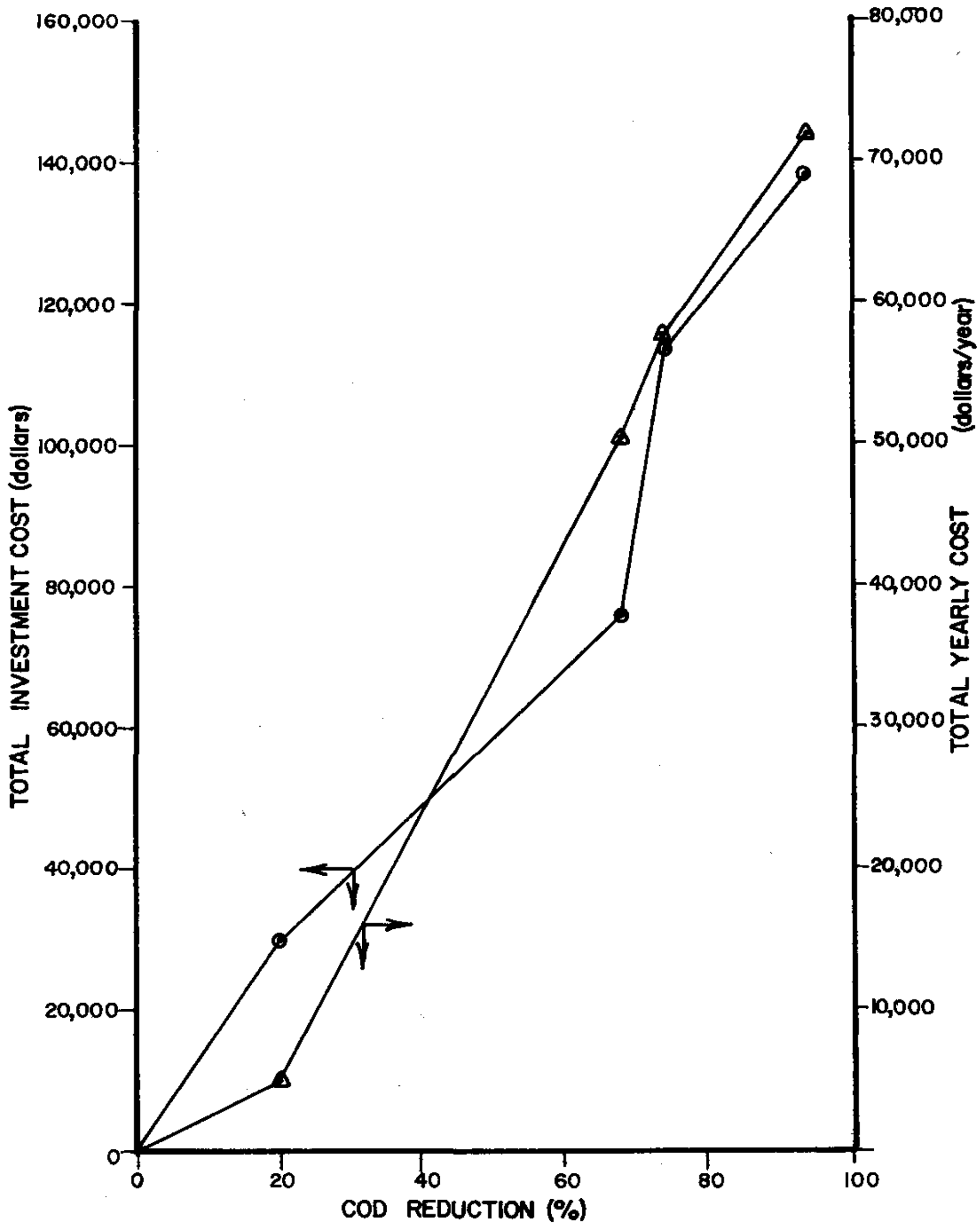


FIGURE 82 TOTAL INVESTMENT COST AND TOTAL YEARLY COST vs COD REDUCTION FOR ALTERNATIVE E

An itemized cost breakdown for the evaporation pond is presented in Table 70.

The reduction benefits for Alternative F include COD and suspended solids reductions of 100 percent.

<u>Related Energy Requirements of Alternative Treatment and Control Technologies</u>

As shown if Table 71, the amount of power required to operate the various treatment alternatives for mill ponds is not considerable, except for Alternative F. The cost of power for the evaporation pond is more than 100 times the cost to operate any of the other treatment alternatives.

The total direct energy costs for Alternative A through E are not great enough to warrant their elimination from consideration. The costs (energy) requirements for Alternative F with respect to the benefit to the environment must be considered carefully.

<u>Non-Water Quality Aspects of Alternative Treatment and Control Technologies</u>

The most significant non-water quality aspect associated with the alternatives for treating mill pond effluents concerns the amount and nature of the solid waste produced. Secondly, but of almost equal significance is the aspect concerning the amount and nature of air pollutants produced. Other important considerations include effects on the operational efficiency of the timber products industry and the aesthetics of the various alternative treatment systems.

Alternative A, no treatment and control, may be considered the base against which the other alternatives can be compared.

The types of sludge produced by Alternative B or C should be readily disposable on land because of their highly organic nature whereas the sludges produced by Alternative D and E are highly inorganic and may be more detrimental to vegetation at disposal sites. The activated carbon used and wasted in Alternative E requires considerable amounts of energy for production and, consequently, the use of Alternative E has an indirect energy cost that does not appear in Table 71. The same is true for the coagulants and flocculants used in Alternatives D and E. No solid wastes are shown to be produced in Alternative F. Yet the solids entering the unit must eventually be handled. It was assumed for the purpose of cost estimates that the sludge would be allowed to accumulate on the pond bottom with the pond being cleaned at infrequent intervals. No costs were assigned to this. Cleaning frequency was assumed to be greater than 20 years.

The air pollutants contributed from the various alternatives will generally vary in proportion to the amount of processing required for the chemicals and the energy requirements. In addition,

TABLE 70

ITEMIZED COST SUMMARY
OF ALTERNATIVE F FOR MILL PONDS
EVAPORATION POND ONLY

INVESTMENT COSTS ITEMS		
1.	Pond & Road	236,516
2.	16 Flotation pumps	268,800
		505,316
3.	Engineering @ 10%	50,532
4.	Contingencies @ 10%	55,585
5.	Land 14.66 ha @ $2470/ha	36,222
	Total Investment Cost	$647,655
MAINTENANCE & OPERATION		
1.	Power	$62,263
2.	Pond Maintenance @ $1040 ha	7,574
	Total Yearly Cost	$128,126

TABLE 71

YEARLY POWER USE AND COSTS
OF ALTERNATIVE TREATMENTS FOR MILL PONDS

Alternative	Power Use (Kw-hrs)	Yearly Cost
A	0	0
B	4,391	$85
C	4,391	$85
D	15,782	$305
E	21,260	$411
F	2,707,087	$52,301

Alternative F may cause measurable amounts of ammonia nitrogen to be released to the air via air stripping.

LOG PONDS

The effluents from log ponds are considered to be derived from natural precipitation, just as in the case for mill ponds. The only differences between mill ponds and log ponds is that the size of the model log pond is 20 ha (50 ac) while the model mill pond was one hectare (three ac), and the quality of the effluent is different. All extraneous streams are assumed to be routed around the log pond. Five alternative treatment schemes for treatment of the waste waters emanating from the log pond were selected.

Cost and Reduction Benefits of Alternative Treatment and Control Technology

Alternative A - It is estimated that 526 million l (139 million gal) of wastes will emanate from the 20 hectare (50 acre) log pond each year, or on the average of 1,441,400 lpd (380,820 gal per day). The COD concentration of the waste is 52 mg/l, yielding a daily COD waste load of 75 kilograms (165 pounds). The suspended solids load for the same waste, based on a concentration of 21 mg/l, is 30 kilograms per day (67 pounds per day).

This alternative requires reasonable process water use and control in order to achieve volume limitations related to precipitation and evaporation rates. The control of the discharge of debris also may require production management procedures, as discussed in Section VII to control the generation of these materials. The physical layout and arrangement of the wet storage facility and the timber processing equipment also influence the possible discharge of debris.

Because of the variety of wet storage operations as they exist in the field, it is not possible to present absolute cost information. The costs of achieving the proposed limitations range between $0 and a maximum of $9,000.

Control of the discharge of floating materials can be achieved by such technologies as floating log booms, submerged weir discharge structures, inverted discharge pipes, or screens.

Control of debris, diameter exceeding 2.54 cm (1.0 in), is usually achieved by installations minimizing activity near points of discharge or by settling action that takes place in the collection area of a wet deck recycle system.

Alternative BI - In Alternative BI the flow from the log ponds is evened out by providing an equalization basin that also functions as an oxidation pond.

The costs of control and treatment for Alternative B1 are as follows:

Total Investment Costs	$96,700
Total Yearly Operating and Maintenance	$ 8,700
Total Yearly Costs	$17,400

An itemized cost breakdown for Alternative B1 is presented in Table 72. The reduction benefit for Alternative B1 involves a COD reduction of 20 percent and a suspended solids reduction of 20 percent.

<u>Alternative</u> <u>B2</u> - Alternative B2 provides a second oxidation pond in series with Alternative B1. The costs of control and treatment for Alternative B2 are as follows:

Incremental Investment Costs	$ 89,400
Total Investment Costs	$186,100
Total Yearly Operating and Maintenance	$ 14,900
Total Yearly Costs	$ 32,000

An itemized cost breakdown for this second oxidation pond is presented in Table 73. The reduction benefits for Alternative B2 include a COD reduction of 60 percent and a suspended solids reduction of 50 percent. The incremental COD reduction is 47 percent and the incremental suspended solids reduction is 40 percent.

A cost-efficiency curve for Alternative B is presented in Figure 83.

<u>Alternative</u> <u>C1</u> - This alternative is the same as Alternative B1. The costs and unit efficiencies are the same.

<u>Alternative</u> <u>C2</u> - Chemical coagulation, flocculation, and sedimentation comprise Alternative C2.

TABLE 72

ITEMIZED COST SUMMARY FOR ALTERNATIVE B-1
FOR LOG PONDS

INVESTMENT COSTS	
ITEMS	
1. Pond	57,456
2. Wet well	2,520
3. 15m of 38cm RCP	588
4. Pump & motor installed	3,780
5. Plug valve & check valve	1,428
	65,772
6. Engineering 10%	6,577
7. Contingencies 10%	7,235
8. Land 6.9ha at $2470/ha	17,100
Total Investment Cost	$96,684
OPERATING & MAINTENANCE	
1. Power	941
2. Pond $1040/ha/yr	6,174
3. Pumping Station Maintenance	1,579
Total Cost	8,694
Total yearly cost for Equalization - Oxidation Pond	$17,396

TABLE 73

ITEMIZED COST SUMMARY FOR ALTERNATIVE B-2
FOR LOG PONDS

INVESTMENT COSTS ITEMS	
1. Pond	57,456
2. 15m of 38cm RCP	588
3. 25cm plug & 25cm check valve	1,428
4. 9m of 25cm C.I. pipe	252
	59,724
5. Engineering 10%	5,972
6. Contingencies 10%	6,570
7. Land 6.9ha at $2470/ha	17,100
Incremental cost	
Cost of alternative B1	96,684
Total Cost	186,050

OPERATING AND MAINTENANCE	
1. Pond Maintenance (6.0ha $1040/ha)	6,174
incremental cost	6,174
Cost of alternative B-1	8,694
Total Cost	14,868

Total yearly cost for second oxidation pond $14,582.84

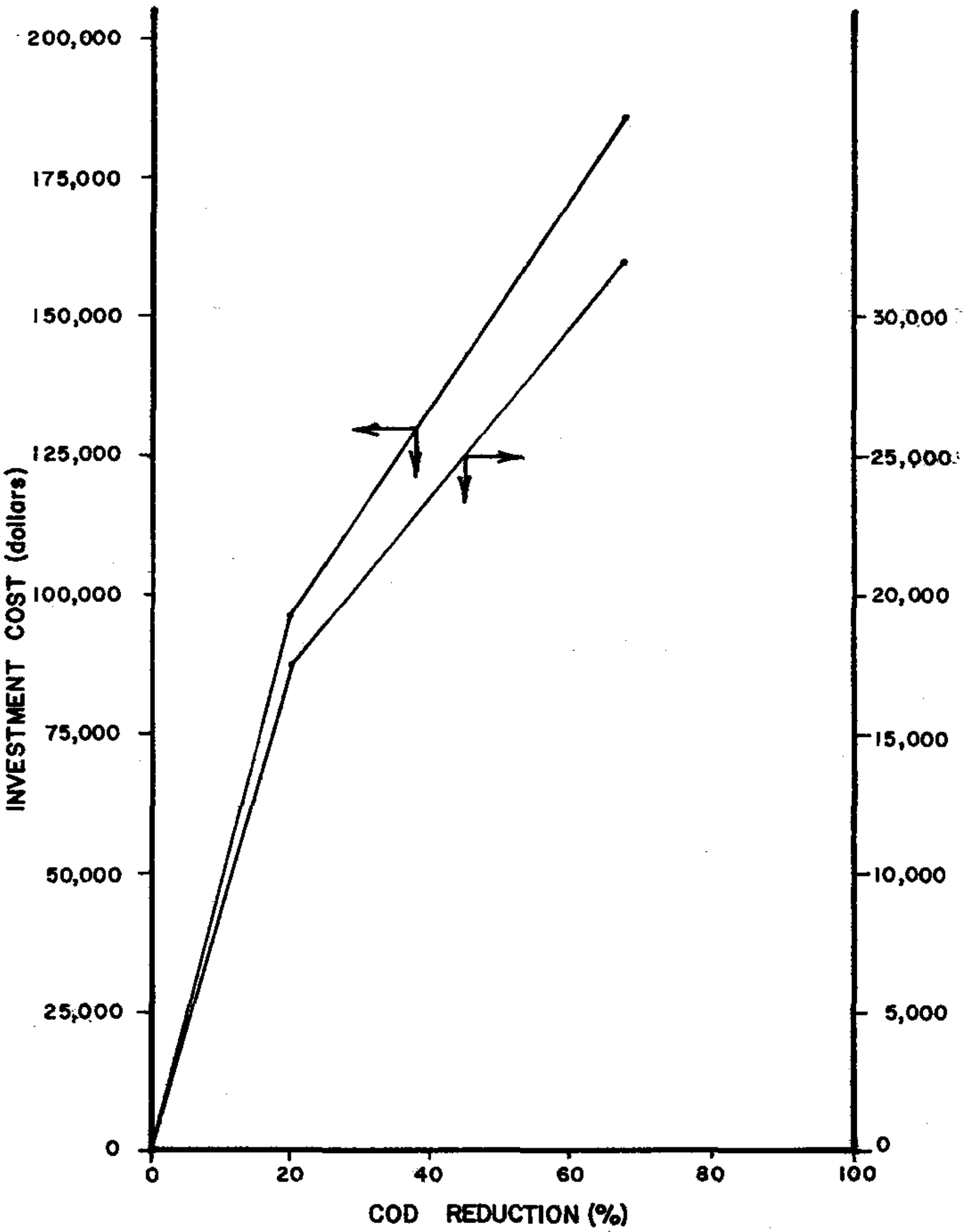


FIGURE 83 TOTAL INVESTMENT COST AND TOTAL YEARLY COST vs COD REDUCTION FOR ALTERNATIVE B

The costs of control and treatment for Alternative C2 are as follows:

Incremental Investment Costs	$122,300
Total Investment Costs	$218,900
Total Yearly Operating and Maintenance	$ 86,058
Total Yearly Costs	$105,800

An itemized cost breakdown for Alternative C2 is presented in Table 74. The reduction benefits for Alternative C2 include a COD reduction of 60 percent and a suspended solids reduction of 90 percent. The incremental COD reduction is 47 percent and the incremental suspended solids reduction is 72 percent. A cost-efficiency curve for Alternative C is presented in Figure 84.

costs and unit efficiencies are the same.

Alternative D2 - This alternative is the same as Alternative C2. The costs and unit efficiencies are the same.

Alternative D3 - This alternative consists of a gravity sand filter for suspended solids removal which will also affect some COD removal.

The costs of control and treatment for Alternative D3 are as follows:

Incremental Investment Costs	$152,500
Total Investment Costs	$371,400
Total Yearly Operating and Maintenance	$104,900
Total Yearly Costs	$138,400

An itemized cost breakdown for the filtration system is presented in Table 75. The reduction benefits for Alternative D3 include a COD reduction of 20 percent and a suspended solids reduction of 90 percent. The incremental COD reduction is six percent and the incremental suspended solids reduction is seven percent.

Alternative D4 - The final process considered in Alternative D is the use of activated carbon for soluble COD removal.

The costs of control and treatment for Alternative D4 are as follows:

Incremental Investment Costs	$408,100
Total Investment Costs	$779,600

TABLE 74

ITEMIZED COST SUMMARY FOR ALTERNATIVE C-2
FOR LOG PONDS

INVESTMENT COSTS		
ITEMS		
1.	Mixing & chemical addition	$13,566
2.	Flocculator	20,076
3.	Sedimentation Equipment	44,940
4.	Building	12,818
5.	Sludge Disposal	8,503
		99,903
6.	Engineering 10%	9,990
7.	Contingencies 10%	10,989
8.	Land 0.55ha at $2470/ha	1,370
	Incremental Cost	$122,252
	Cost of alternative C-1	96,684
	Total investment cost	$218,936
OPERATION & MAINTENANCE		
1.	Power	618
2.	Maintenance	5,028
3.	Chemicals	29,005
4.	Labor	36,288
5.	Sludge Disposal	6,425
	Incremental Cost	77,364
	Cost of alternative C-1	8,694
	Total costs	86,058

Total yearly costs of chemical coagulation - flocculation - sedimentation $88,367

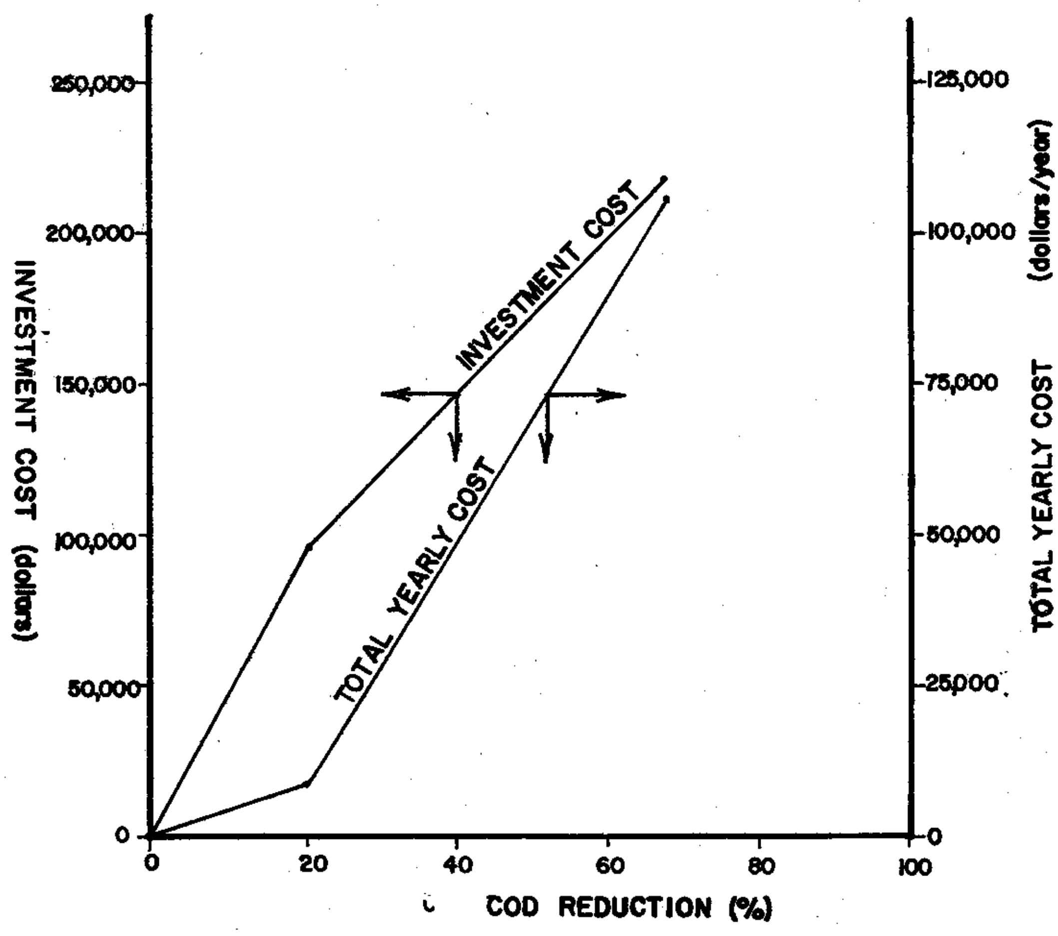


FIGURE 84 TOTAL INVESTMENT COST AND TOTAL YEARLY COST vs COD REDUCTION FOR ALTERNATIVE C

TABLE 75

ITEMIZED COST SUMMARY FOR ALTERNATIVE D-3
FOR LOG PONDS

INVESTMENT COSTS ITEMS		
1.	Filter chambers (2)	56,330
2.	Sand (78cm)	8,089
3.	Gravel (46cm)	4,855
4.	Piping & fittings & valves	9,265
5.	Backwash Pump	12,600
6.	Building	31,190
7.	Sludge disposal equipment	1,699
		124,028
8.	Engineering 10%	12,403
9.	Contingencies 10%	13,643
10.	Land 0.98ha at $2470/ha	2,430
	Incremental cost	$152,504
	Costs of alternative D1 & D2	218,936
	Total cost	371,440
OPERATING & MAINTENANCE COSTS		
1.	Power	70
2.	Maintenance	5,957
3.	Sludge disposal costs	12,840
	Incremental cost	18,867
	Costs of alternative D1 & D2	86,058
	Total cost	104,925

Total yearly costs of gravity sand filtration $32,592

Total Yearly Operating and Maintenance	$173,800
Total Yearly Costs	$244,100

An itemized cost breakdown for the activated carbon system is presented in Table 76. The reduction benefits for Alternative D4 include a COD reduction of 75 percent and no suspended solids reduction. The incremental COD reduction is 20 percent and the incremental suspended solids reduction is zero.

A cost-efficiency curve for Alternative D is presented in Figure 85.

Alternative E - Alternative E consists of the placement of spray evaporators on the existing log pond and the enlargement of the berm.

The costs of control and treatment for Alternative E are as follows:

Total Investment Costs	$1,074,300
Total Yearly Operating and Maintenance	$ 166,000
Total Yearly Costs	$ 262,700

An itemized cost breakdown for Alternative E is presented in Table 77. The reduction benefits for this alternative include 100 percent COD reduction and 100 percent suspended solids reduction. The incremental reductions are the same.

Related Energy Requirements of Alternative Treatment and Control Technologies

As shown in Table 78, the amount of power required to operate the various alternatives for log ponds is not considerable except for Alternative E. As in the consideration of mill ponds, the power costs to spray evaporate the excess water from the log pond are greater than any of the other treatment techniques. However, because of the modified evaporation-log pond, the cost is not in proportion to the flow rate. The cost of heat to regenerate the activated carbon in Alternative D has been converted to kilowatt hours and is shown in Table 78.

There is considerable discussion in the industry concerning the possibility of removing logs from the water, including log ponds, and utilizing land decking entirely. One study showed that three dollars per two cu m (about 1,000 bd ft) could be saved when dry decking of logs was used in place of a log pond. This savings was determined on the basis of saved manpower. In another study at a different mill site, more factors were considered. The

TABLE 76

ITEMIZED COST SUMMARY FOR ALTERNATIVE D-4
FOR LOG PONDS

INVESTMENT COSTS ITEMS	
1. 3800 $\frac{cum}{day}$ pump w/15 hp motor	2,100
2. Contact columns & piping & carbon handling equip.	63,000
3. Initial carbon charge	22,260
4. Regeneration equipment	213,360
5. Building	36,490
	337,210
6. Engineering 10%	33,721
7. Contingencies 10%	37,093
8. Land 0.04ha @ $2470/ha	100
Incremental cost	$408,124
Cost of alternative D1,D2, & D3	371,440
Total costs	779,564

OPERATING & MAINTENANCE (6 months operation)	
1. Power	932
2. Carbon handling equipment	13,440
3. Carbon regeneration	49,981
Fuel	1,050
Power	630
4. Building	2,890
Incremental cost	68,923
Cost of alternative D1,D2, & D3	104,925
Total Cost	173,848
Total yearly cost for activated carbon	105,654

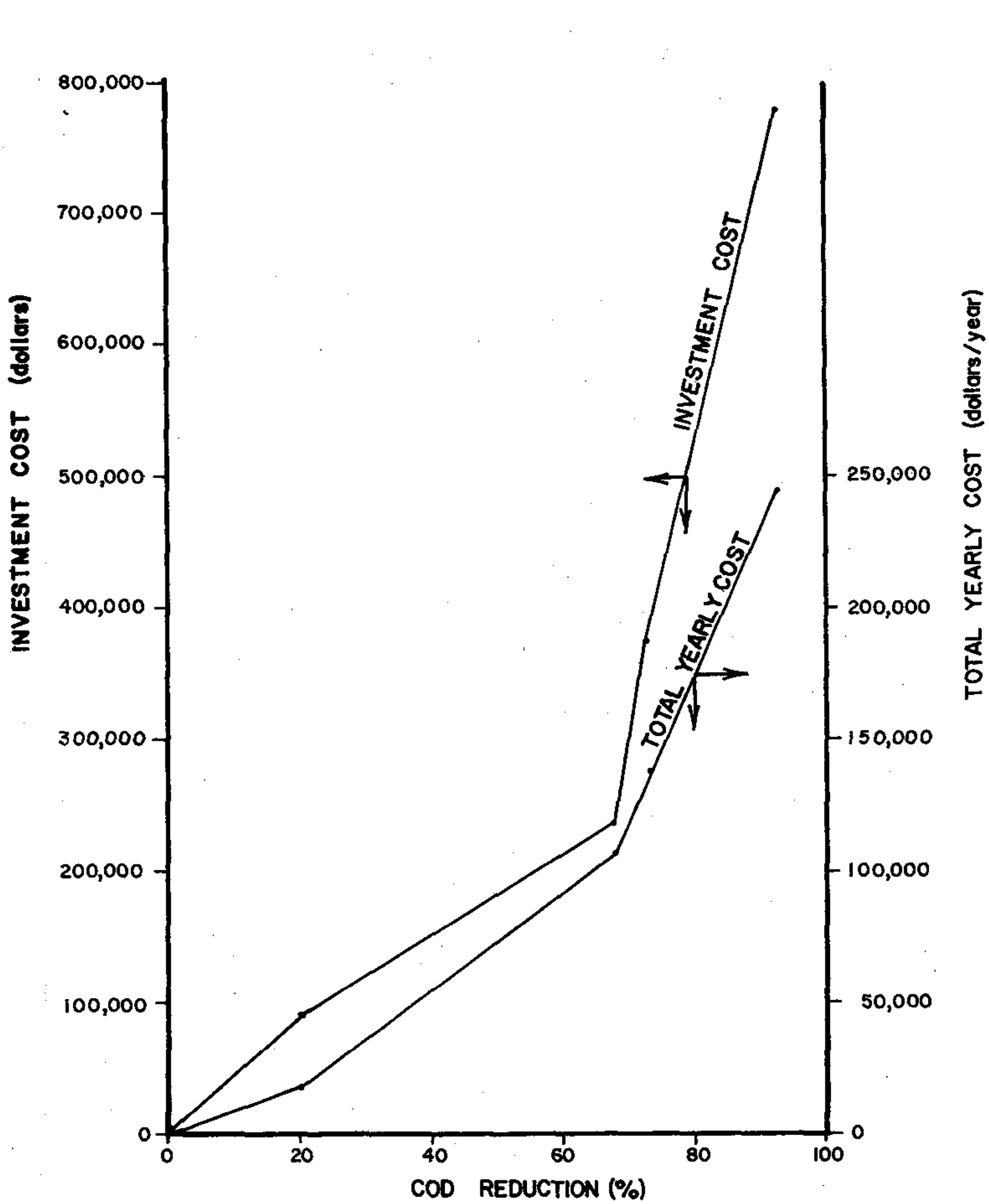


FIGURE 85 TOTAL INVESTMENT COST AND TOTAL YEARLY COST vs COD REDUCTION FOR ALTERNATIVE D

TABLE 77

ITEMIZED SUMMARY FOR ALTERNATIVE E
FOR LOG PONDS

INVESTMENT COSTS ITEMS		
1.	Spray evaporators 42 @ $16,800 each	705,600
2.	Alterations of log pond	177,116
3.	Engineering 10%	88,272
4.	Contingencies 10%	97,099
5.	Land 2.5ha @ $2470/ha	6,170
	Total Costs	1,074,257

OPERATING & MAINTENANCE		
1.	Additional Maintenance cost	2,591
2.	Power	163,440
	Total Costs	166,031

Total Yearly costs for spray evaporators on the log pond $262,714

TABLE 78

YEARLY POWER USE AND COSTS FOR ALTERNATIVE TREATMENT FOR LOG POND

Alternative	Power Use (Kw-hrs)	Yearly Costs (dollars)
A	0	0
B	72,511	1,400
C	80,086	1,600
D *	211,100	4,100
E	8,459,652	163,440

* Fuel for activated carbon recharge = 54,326 Kw-hrs = $1100

energy required to operate a dry decking operation 0.5 miles from the processing plant was compared to the energy required to generate water storage of the same logs at the mill site. Electrical costs were about the same, but it was estimated that the amount of fuel required to operate the dry deck would be 300,000 l (80,000 gal per year) for the dry deck and 40,000 l per year (11,000 gal per year) in the water storage.

The comparison of energy requirements for land decking as opposed to water storage will depend on the specific requirements at each mill location. However, it was observed in the current study that sorting and storing of logs in water generally requires less energy and effort than the same operation on land. The above cited figures tend to support this observation, yet the long haul distance to the land deck in the above example makes the amount of energy required for land decking larger than would normally be expected.

Non-Water Quality Aspects of Alternative Treatment and Control Technologies

The significant non-water quality aspects associated with log ponds are the same as those for mill ponds, i.e., solid wastes, air pollutants, operational efficiency, and aesthetics. In general, these aspects are similar to those for mill ponds, but the quantities are significantly greater because of the larger pond size, higher flow rates, and different waste characteristics.

Alternative D for log ponds includes on-site regeneration of activated carbon, so the amount of activated carbon disposed of as a solid waste is less, but the amount of power required for regeneration of the carbon is higher. The aesthetics of the large treatment units may be negative and the cost to the industry is more than for treatment of the mill pond effluent.

The decision of whether to remove the logs from the water entirely can also depend on non-water quality parameters. These were studied by Schaumberg and the estimates of the quantities of these solid and air pollutants are shown in Table 79. The difference in the amounts of these materials produced for the two log storage techniques is considerable.

WET DECKING

The effluents from wet decking operations are similar in character to those of mill and log ponds. Because the water used on the wet decks was assumed to be recycled, the only time that an effluent occurs is when the runoff volume from precipitation exceeds the storage capacity of the recycle pond. With these restrictions, the wet deck effluent has the same flow character and volumes as the mill and log ponds. The precipitation on the wet deck is highly variable with the area of the country and the amount of flow from the wet deck is directly proportional to the area of the wet deck and recycle pond. Because the typical wet

TABLE 79

NON-WATER QUALITY WASTES GENERATED FOR LAND DECKING AND WATER STORAGE

Pollutant	Land Deck Emission (kilograms/year)	Water Storage Emissions (kilograms/year)
Solid Wastes*	400	68,000
Air Pollutants		
Particulates	450	50
Oxides of sulfur	1000	140
Carbon Monoxide	9000	1,300
Hydrocarbons	1400	180
Oxides of Nitrogen	13500	1,800

*Bark @ 240 kg/cu m

deck may have an area from one half hectare to 50 ha (one acre to 120 ac) and it may be located in almost every location in the country with the exception of the arid Southwest, it is not possible to decide on typical flows from the wet deck. For this reason, two flows were chosen to represent one small wet deck and one large wet deck. These flows are three and 44 l/sec (50 and 694 gpm) for six months of the year. These are the same flows as chosen for mill and log ponds, respectively.

Because the treatment schemes for the treatment of waste waters from wet decks are virtually identical to those chosen for mill and log ponds, the designs and costs for those units are applicable to wet decks. All costs for wet deck treatment units are the same as those for mill and log ponds previously discussed. A summary of costs for the two flows is presented in Table 80.

<u>Related Energy Requirements of Alternative Treatment and Control Technologies</u>

The amount of power required to operate the various alternative treatment units are the same as those discussed for mill ponds and log ponds. Since wet decking is a type of land decking, the energy requirements discussed in land decking and water storage are also applicable to wet decking. The power or energy required to sort and move the logs on land is considerably higher than the energy required to sort and move the logs in water. The energy required to sprinkle the log deck is small compared to the energy required to move and sort the logs.

The non-water quality aspect of wet decking are the same as those for mill ponds and log ponds. The wet decks themselves may have different aesthetic value than water storage, but pollutant loads to the air and land from the treatment alternatives are the same as for mill ponds or log ponds.

<u>LOG WASHING</u>

The log washing operation developed in Section V possessed the following characteristics:

1. The log wash operates 16 hours per day, 250 days per year.

2. Existing facilities are the log washer itself including the pump and appropriate piping.

3. No treatment is presently given the log washer effluent.

4. Volumetric rate of flow is 25 l/sec (400 gpm).

5. Volume of logs washed per day equals 280 cu m (9,887 cu ft).

TABLE 80

COSTS SUMMARY FOR WET DECKING

Alternatives	Incremental Investment Cost		Total Investment Cost		Total Yearly Op. Cost		Total Yrly Costs	
	3 l/sec	44 l/sec	3 l/sec.	44 l/sec	3 l/sec	44 l/sec	3 l/sec	44/sec
A (no treatment	0	0	0	0	0	0	0	0
B,C1,D1,E1 (recycle-equalization sedimentation)	29,200	96,700	29,200	96,700	2,400	8,700	5,000	17,400
C2 (oxidation pond #2)	18,300	89,400	47,500	186,000	3,200	14,900	7,400	32,000
D2,E2 (chemical coagulation flocculation)	47,200	122,300	76,500	218,900	43,400	86,058	50,200	105,800
E3 (filtration)	36,900	152,500	113,400	371,500	47,400	104,900	57,500	138,400
E4 (activated carbon)	23,600	408,100	137,000	779,600	59,400	173,800	71,700	144,100
F (evaporation pond)	647,700	-	647,700	-	69,800	-	128,100	-

The assumptions made for the development of costs for control and treatment technologies for the treatment alternatives for log washing include the following:

1. Adequate land is available on site for treatment facilities.

2. No extensive changes are required in the mill feed to allow treatment of the effluent from the log washing operation.

Alternative A - This alternative consists of no control or treatment. It requires no costs and results in no reduction benefits. The total kilograms of COD per day resulting from the application of Alternative A are 140 (310 lbs) while the suspended solids load discharged would be 106 kilograms per day (234 pounds per day).

Alternative B - This alternative consists of total recycle of the log wash effluent. Total recycle can be achieved by sedimentation of settleable solids and screening of the suspended solids. Sludge ponds to thicken settled material are also required. A summary of the costs of treatment and control follow. Itemized costs are given in Table 81.

Costs of Treatment and Control

Total Investment Costs	$27,600
Total Yearly Operating and Maintenance	$14,700
Total Yearly Costs	$17,200

Reduction benefits: Reduction benefits of 100 percent of all pollutants are achieved.

Related Energy Requirements of Alternative Treatment and Control Technologies

No information is available regarding energy requirements for log washing. However, the total energy requirements for a sawmill producing 280 cu m per day (10,000 cu ft per day) are approximately 28,000 kw hrs/ day of energy.

At a cost of 2.3 cents per kilowatt hour, energy cost for a 280 cu meter (10,000 cu ft) per day mill equals approximately $161,000 dollars per year. The associated yearly energy costs for the recommended control and treatment alternatives are estimated to be:

TABLE 81

COSTS OF CONTROL AND TREATMENT, ALTERNATIVE B FOR LOG WASHING OPERATIONS

INVESTMENT COSTS ESTIMATE

Item		Costs
1. Screen, horizontal conveyor type, complete		$3,108
2. Settling tank 200 cu m (7000 ft^3) complete		10,920
3. Screen, vibrating, complete		3,108
4. Sludge pump		840
5. Sludge Pond		4,872
6. Engineering		2,285
7. Contingencies		2,513
	Total	$27,646

OPERATING COSTS ESTIMATE

Item		Costs
1. Operation and Maintenance		$13,780
2. Electricity		899
	Total	$14,679

Alternatives	Cost
A	0
B	$899

Non-Water Quality Aspects

Non-water quality aspects can be expected to be minimal. The disposal of settled materials should be accomplished by landfill.

SAWMILLS AND PLANING MILLS

For the purposes of this report the sawmill and planing mill segment of the timber products processing industry has been defined to exclude the following items or operations:

1. Piles of fractionalized wood.
2. Log storage and handling.
3. Debarking.
4. Log washing.
5. Steam and power generating facilities.
6. Finishing operations.

The above operations including control and treatment technology and associated costs are discussed elsewhere in this document.

Cost and Reduction Benefits of Alternative Treatment and Control Technologies

The specific assumptions utilized in the development of costs of control and treatment for sawmills and planing mills are the following:

1. Water used for cooling saws and lubricating belts is minimized.
2. No water is used in cleanup of floors.
3. Equipment leakage is controlled.
4. Cooling water for condensers, turbines and pumps is removed from the point of use by closed pipes as is boiler blowdown and ion exchange media backwash.
5. Lumber finishing compounds such as coatings, stains or water proofing compounds are recycled as is washwater developed during cleaning of the applicators.

6. Preservative dip tanks are covered to prevent rain from entering them; lumber is allowed to drip-dry prior to stacking, or drippage is collected and returned to the dip tank.

7. Steam condensate is returned from drying kilns to the boiler.

The above assumptions are considered to be valid in that in a well managed mill these are generally considered standard practice. On the basis of these assumptions, no further control and treatment is required to acheive a zero discharge limitation and no costs of control and treatment are thereby incurred.

FINISHING

Two models were selected in Section V as being representative of fabricating operations. Model 1 utilizes one spreader, one finger jointer and one mixing vessel, all of which require daily cleanup using a total of 750 l (200 gal) of water. Model 2 consists of five double roller spreaders, three finger jointers, one catalyst mixer, and two resin mixing tanks. The resulting daily waste water production from Model 2 is 5700 l (1500 gal). Both models are assumed to operate seven days per week, 52 weeks per year.

Cost and Reduction Benefits of Alternative Treatment and Control Technologies

In addition to the assumptions listed at the beginning of this section, the following assumptions are made regarding costs of the various alternatives:

1. No control or treatment presently exists.

2. For alternatives requiring land, it is assumed that it is available at $2500 per hectare.

3. Discharge to a municipal sewer system entails no hookup charges and a maximum monthly charge of $25.

Alternative A - This alternative consists of no waste water control of treatment. Therefore, there are no costs of treatment and no reduction benefits.

Alternative B - This alternative consists of screening followed by discharge to an evaporation pond. Evaporation is accomplished by spray evaporators where precipitation exceeds evaporation plus waterflow. A summary of the costs and reduction benefits associated with this alternative is presented below. These costs represent average costs for all five regions, rounded to the nearest hundred dollars. A detailed breakdown of investment and operating costs is given in Table 82.

Model 1

Costs of Treatment and Control

Total Investment Costs	$27,000
Total Yearly Operating and Maintenance	$ 1,900
Total Yearly Costs	$ 4,200

Reduction Benefits: One hundred percent reduction is achieved.

Model 2

Costs of Treatment and Control

Total Investment Costs	$47,800
Total Yearly Operating and Maintenance	$ 4,600
Total Yearly Cost	$ 8,900

Reduction benefits: One hundred percent reduction of pollutant discharge is achieved.

Alternative C - This alternative consists of screening followed by discharge to a holding tank. Incineration is then accomplished by spraying the glue wastes on the hog fuel prior to burning. It is assumed that a hogged fuel furnace is presently on site. A summary of costs of control and treatment and reduction benefits are presented below. Detailed cost information is presented in Table 83.

Model 1

Costs of Treatment and Control

Total Investment Costs	$9,000
Total Yearly Operating and Maintenance	$3,400
Total Yearly Costs	$4,200

Model 2

Costs of Treatment and Control

Total Investment Costs	$17,200
Total Yearly Operating and Maintenance	$ 4,300

TABLE 83

COSTS OF CONTROL AND TREATMENT
FOR ALTERNATIVE C FOR FABRICATION OPERATIONS

Model 1

Investment Cost Estimate

Item		Cost
1. Screens		$2,300
2. Screen Building, Foundation		4,682
3. Pump		210
4. Sump		213
5. Engineering		741
6. Contingencies		815
	TOTAL	$8,961

Operating Cost Estimate

Item		Cost
1. Electricity		$ 20
2. Operation & Maintenance		3,374
	TOTAL	$3,394

Model 2

Investment Cost Estimate

Item	Cost
1. Screen	$2,300
2. Screen Building, Foundation	4,682
3. Pump	210
4. Sump	6,982
5. Engineering	1,417

TABLE 83 (Cont.)

Model 2 Cont.

Investment Cost Estimate

Item		Cost
6. Contingencies		$1,559
	TOTAL	$17,150

Operating Cost Estimate

Item		Cost
1. Electricity		$ 30
2. Maintenance & Operation		4,266
	TOTAL	$4,296

Total Yearly Cost $ 5,800

Reduction Benefits: One hundred percent reduction of pollutant discharge is accomplished.

Alternative D - This alternative consists of screening to remove large glue solids followed by landspreading. A summary of the costs of control and treatment and the reduction benefits is presented below. A detailed description of investment and operating costs is presented in Table 84.

Model 1

Costs of Treatment and Control

Total Investment Costs	$9,900
Total Yearly Operating and Maintenance	$1,800
Total Yearly Cost	$2,700

Reduction Benefits: Reduction benefits may be assumed to be 100 percent.

Model 2

Costs of Treatment and Control

Total Investment Cost	$12,200
Total Yearly Operating and Maintenance	$11,100
Total Yearly Cost	$12,200

Reduction Benefits: One hundred percent reduction of pollutant discharge is achieved.

Alternative E - This alternative consists of screening followed by discharge to a holding tank and recycle of the settled glue waste water for reuse in cleaning. Piping is provided to provide makeup water, bleedoff to incineration and use of a portion of the waste water for glue mixing. It is assumed that makeup water is available from existing water distribution system and that a hogged fuel burner is presently on site. A summary of costs and reduction benefits is presented below. A detailed breakdown of investment and operating costs is presented in Table 85.

Model 1

Costs of Treatment and Control

Total Investment Costs $10,900

TABLE 84

COSTS OF CONTROL AND TREATMENT
FOR ALTERNATIVE D FOR FABRICATION OPERATIONS

Model 1

Investment Cost Estimate

Item		Cost
1. Screen		$2,300
2. Screen Building, Foundation		4,682
3. Holding Tank & Foundation		945
4. Pump		250
5. Engineering		818
6. Contingencies		900
	TOTAL	$9,895

Operating Cost Estimate

Item		Cost
1. Electricity		$ 20
2. Operation & Maintenance		1,787
	TOTAL	$1,807

Model 2

Investment Cost Estimate

Item		Cost
1. Screen		$2,300
2. Screen Building, Foundation		4,682
3. Holding Tank & Foundation		2,835
4. Pump		250
5. Engineering		1,007
6. Contingencies		1,107
	TOTAL	$12,181

TABLE 84 (Cont.)

Model 2 Cont.

Operating Cost Estimate

Item		Cost
1. Electricity		$ 30
2. Operation and Maintenance		11,073
	TOTAL	$11,103

TABLE 85

COSTS OF CONTROL AND TREATMENT
FOR ALTERNATIVE E FOR FABRICATION OPERATIONS

Model 1

Investment Cost Estimate

Item		Cost
1. Screens		$2,300
2. Screen Building, Foundation		4,682
3. Holding Tank, Foundation		735
4. Sump		153
5. Sump Pump		420
6. Pump, Piping & Controls for Incineration		420
7. Piping & Valves		336
8. Engineering		905
9. Contingencies		995
	TOTAL	$10,946

Operating Cost Estimate

Item		Cost
1. Electricity		$ 12
2. Operation & Maintenance		313
	TOTAL	$ 325

Model 2

Investment Cost Estimate

Item	Cost
1. Screen	$2,300
2. Screen Building, Foundation	4,682

TABLE 85 (Cont.)

Model 2 Cont.

Item		Cost
3. Holding Tank, Foundation		$1,995
4. Sump		370
5. Sump Pump		420
6. Pump, Piping Controls for Incineration		420
7. Piping & Valves		336
8. Engineering		1,052
9. Contingencies		1,158
	TOTAL	$12,733

Operating Cost Estimate

Item		Cost
1. Electricity		$ 12
2. Operating & Maintenance		411
	TOTAL	$ 423

Total Yearly Operating and Maintenance	$ 300
Total Yearly Cost	$ 1,300

Reduction benefits: 100 percent reduction is achieved.

Model 2

Costs of Treatment and Control

Total Investment Costs	$12,700
Total Yearly Operating and Maintenance	$ 400
Total Yearly Costs	$ 1,600

Reduction benefits: 100 percent reduction is achieved.

Alternative F - This alternative consists of discharge to a municipal sewer. For the purpose of determining costs of municipal treatment, it is assumed that there are no hookup charges and that a minimum monthly rate of twenty-five dollars is charged for both model systems.

Costs of Treatment and Control

Total Yearly Operating and Maintenance	$300
Total Yearly Costs	$300

Reduction benefits: One hundred percent reduction is achieved.

Cost Summary for Alternatives - A summary of costs for the treatment alternatives is presented in Table 86.

Related Energy Requirements of Alternative Treatment and Control Technologies

The industries represented by this subcategory are extremely diverse in terms of product produced and energy consumed. Therefore, no information available which is representative of energy requirements for fabricating operations.

The following costs are the anticipated annual energy costs the the alternative treatment and control technologies:

TABLE 86 SUMMARY OF ALTERNATIVE COSTS FOR FABRICATION OPERATIONS

*Summary of Alternative Costs, Model 1

Alternative	Percent Reduction	Investment Costs	Total Yearly Operating Costs	Total Yearly Operating Costs
A	0	0	0	0
B	100	$27,000	$1,820	$4,200
C	100	$ 9,000	$3,400	$4,200
D	100	$ 9,900	$1,800	$2,700
E	100	$10,900	$ 300	$1,300
F	100	0	$ 300	$ 300

*Summary of Alternative Costs, Model 2

Alternative	Percent Reduction	Investment Costs	Total Yearly Operating Costs	Total Yearly Operating Costs
A	0	0	0	0
B	100	$47,800	$ 4,600	$ 8,900
C	100	$17,200	$ 4,300	$ 5,800
D	100	$12,200	$11,100	$12,200
E	100	$12,700	$ 400	$ 1,600
F	100	0	$ 300	$ 300

*Average costs for all five regions

Alternative	Model 1 Costs	Model 2 Costs
A	0	0
B	144	1,085
C	20	30
D	20	30
E	12	12
F	0	0

Non-Water Quality Aspects

The non-water quality aspects of the various alternatives are anticipated to be negligible. However, disposal of glue wastes by landspreading must be controlled carefully to avoid contamination of ground water and surface water. Incineration should be monitored to determine any impact on air quality. Alternative E, wash water reuse, will provide the least impact potential for both water and non-water quality aspects and is also the least energy consuming treatment technology.

INSULATION BOARD SUBCATEGORIES

The costs estimates contained in this document are based on actual preliminary cost estimates for waste treatment systems defined in Section VII for a model plant defined in Section V (Water Use and Waste Characterization) of the insulation board industry. Land costs were assumed to be $2000 an acre based on the assumption that insulation board plants are located on the outskirts of medium size towns. The design criteria for the various treatment technologies presented below are essentially the same for all subcategories. Therefore, unless otherwise noted the description of the treatment alternatives can be considered applicable to all subcategories.

The insulation board industry was subcategorized into two subcategories as previously discussed. The raw waste water discharge for a plant of each subcategory appear below:

Subcategory	Flow l/kkg	Production kkg/Day	BOD kg/kkg	TSS kg/kkg
I	54,250	270	12.5	10
II	54,250	270	37.5	10

It should be noted that these flows and loads occur after primary clarification since the plants are all assumed to have primary clarifiers. Also, there is assumed to be 2700 kg/day (6,000 lbs/day) (dry weight) at 3 percent consistency 10 kg/kkg (20 lbs/ton) of sludge from the existing clarifier, which is disposed of by an existing system. The loads and flows given do not include cooling water, boiler blowdown, roof runoff, yard runoff, fire fighting, or waters from raw material handling and storage operations.

COST AND REDUCTION OF ALTERNATIVE TREATMENT AND CONTROL TECHNOLOGIES

Alternative A - This alternative consists of no treatment of the waste water discharged from the model plant's primary clarifier.

There is no cost involved and no reduction benefits.

Alternative B - This alternative consists of aerated lagoons of 19 day detention time followed by a settling pond with 24 hour detention time added to Alternative A. This alternative provides for an 85 percent BOD reduction in the waste water based on accepted design criteria and a conservative estimate of reaction rates. The sludge from the settling pond will be removed once a year by dredging and trucking to landfill or by land spreading. A detailed cost summary is presented in Table 87.

The costs involved for the alternative are as follows:

	Subcategory I	Subcategory II
Initial Investment	$380,000	$380,000
Yearly Operation and Maintenance	34,500	91,300
Total Yearly Cost	$ 87,300	$155,100

This system provides for an 85 percent reduction of BOD and 70 percent reduction of suspended solids.

Alternative C1 - This alternative consists of an activated sludge system with sludge handling facilities. Waste sludge is pumped to a thickener with a loading rate of 4100 lpd per sq m (100 gpd/sq ft). The underflow at a consistency of 5 percent is dewatered by a coil drum vacuum filter prior to which filter aids are added. The dewatered sludge then disposed of in a landfill.

The activated sludge system was designed using the following criteria: mixed liquor suspended solids is equal to 2,500 mg/l, loading rate for the aeration tank is equal to 0.2 kg of BOD per kg of MLSS, loading rate for the secondary clarifier is equal to 1900 lpd. The aeration requirements were calculated using standard design parameters and nutrient addition and pH adjustment were provided. A detailed cost summary is presented in Table 88.

	Subcategory I	Subcategory II
Total Investment	$954,100	$1,160,800

TABLE 87

ITEMIZED COST SUMMARY
FOR ALTERNATIVE B FOR INSULATION BOARD

INITIAL INVESTMENT COSTS

ITEM	COST Subcategory I	COST Subcategory II
Aerated Lagoon	$380,032	$380,032
Settling Pond	35,879	35,879
Pump	2,100	2,100
Aerators	50,400	117,600-151,200
Land 4.0 hectares(9.8 acres)	19,600	19,600
Engineering and Contingencies	98,366	119,534
	$586,377	$667,689-708,345
OPERATION AND MAINTENANCE		
Operation and Maintenance	$ 4,221	$4,221
Power	30,300	68,176-87,114
	$34,521	$72,397

Yearly Operating and Maintenance	216,700	287,800
Total Yearly Cost	$302,600	$392,300

A 90% reduction in BOD and 70% reduction of suspended solids is achieved by this system.

Alternative C2 - This alternative consists of an addition of an aerated lagoon with a quiescent settling area to Alternative C1. The addition of an aerated lagoon, based on design parameters presented in Alternative B, will have an eight day detention time. The quiescent area will be dredged once a year and solids trucked to landfill. A detailed cost summary is presented in Table 89. The costs for this alternative are as follows:

	Subcategory I	Subcategory II
Incremental Investment	$ 236,500	$ 236,500
Total Investment	1,190,600	1,397,300
Yearly Operation and Maintenance	235,900	306,900
Total Yearly Cost	$ 343,100	$ 432,700

An incremental reduction of BOD of 70% and no incremental suspended solid reduction is achieved by this system. An overall reduction of BOD of 97% and SS of 70% is realized. Cost efficiency curves for Alternative C are shown in Figures 86, 87, 88.

Alternative D1 - This alternative consists of an activated sludge system and sludge handling facilities as described in Alternative C1. A detailed cost summary is presented in Table 88.

Alternative D2 - This alternative provides a suspended solids removal system for secondary effluent of Alternative D1 so that a portion of this water can be recycled back to the process. Suspended solids are removed by use of a multi-media filter with backwashing facilities. The filter is designed for 100 percent of the flow with a surface loading rate of 163 l/ sq m/min (4.0 gal/sq ft/min). Backwashing is accomplished with filtered water. Although this system is designed for recirculation of 100 percent of the effluent, complete recycle may not be feasible. Therefore, for this system only 70 percent of the secondary clarifier discharge will be recycled back to the plant. A detailed cost summary is presented in Table 90. The costs involved for this alternative are as follows:

TABLE 88 ITEMIZED COST SUMMARY FOR ALTERNATIVES C-1, AND D-1 FOR INSULATION BOARD

ITEM	INITIAL INVESTMENT COSTS	
Activated Sludge	Subcategory I	Subcategory II
Nutrient & pH Control Equip.	$21,420	$21,420
Lagoon (w/Liner)	53,088	101,004-120,597
Secondary Clarifier (w/skimmer)	111,300	111,300
Aerators	50,400	117,600-151,200
Pipes, Valves & Fittings	63,000	63,000
Electrical (Miscellaneous)	63,000	63,000
Instrumentation	42,000	42,000
Sub-Total - Activated Sludge	$404,208	$519,324-572,517
Sludge Disposal Facilities		
Thickener (w/skimmer)	$70,980	$70,980
Polymer Feed Equip.	10,920	10,920
Coil Filters	223,440	223,440
Belt Conveyor	36,960	36,960

TABLE 88 (Cont.)

Item	Subcategory I	Subcategory II
Building	37,800	37,800
Sub-Total - Sludge Disposal	$380,100	$380,100
Engineering & Contingencies	164,705	188,879 - 200,050
Land	5,100 (1.0 ha)	7,280 - 8,160 (1.7 ha)
TOTAL INVESTMENT	$954,113	$1,095,583 - 1,160,827

TABLE 89

ITEMIZED COST SUMMARY
FOR ALTERNATIVE C-2 FOR INSULATION BOARD

Total Investment Costs

ITEM	COST Subcategory I	COST Subcategory II
Aerated Lagoon	$147,000	$147,000
Aerators	40,320	40,320
Land (2.0 ha.)	9,800	9,800
Engineering and Contingencies	39,337	39,337
Incremental Investment	$236,457	236,457
Cost C-1	954,113	1,095,583-1,160,827
TOTAL INVESTMENT	$1,190,570	$1,332,040-1,397,284
Operation and Maintenance		
Operation and Maintenance	$ 4,013	$ 4,013
Power	15,150	15,150
Incremental Investment	19,163	19,163
Cost C-1	216,690	264,068-287,752
TOTAL OPERATION AND MAINTENANCE	$ 235,853	$ 283,231-306,915

TABLE 90

ITEMIZED COST SUMMARY FOR
ALTERNATIVE B-2 FOR INSULATION BOARD

ITEM	COST	
	Subcategory I	Subcategory II
Mixed Media Pressure Filter (w/media)	58,800	58,800
Filtered Water Storage Tank	6,720	6,720
Back Wash Pump	10,800	10,800
Pipes Valves Fittings	8,400	8,400
Electrical (misc.)	1,680	1,680
Instrumentation	8,400	8,400
Control Building Addition	10,800	10,800
Land (.012 Hec.)	60	60
Incremental Investment	105,660	105,660
COST D-1	954,113	1,095,583
TOTAL INVESTMENT	1,059,773	1,201,243
	Operation and Maintenance	
Operation and Maintenance	3,108	3,108
Media Replacement	1,680	1,680

TABLE 90 (Cont.)

Item	Cost	
	Subcategory I	Subcategory II
Power	1,344	1,344
Incremental Investment	6,132	6,132
Cost D-1	216,690	264,068
TOTAL OPERATIONS & MAINTENANCE	222,822	270,200

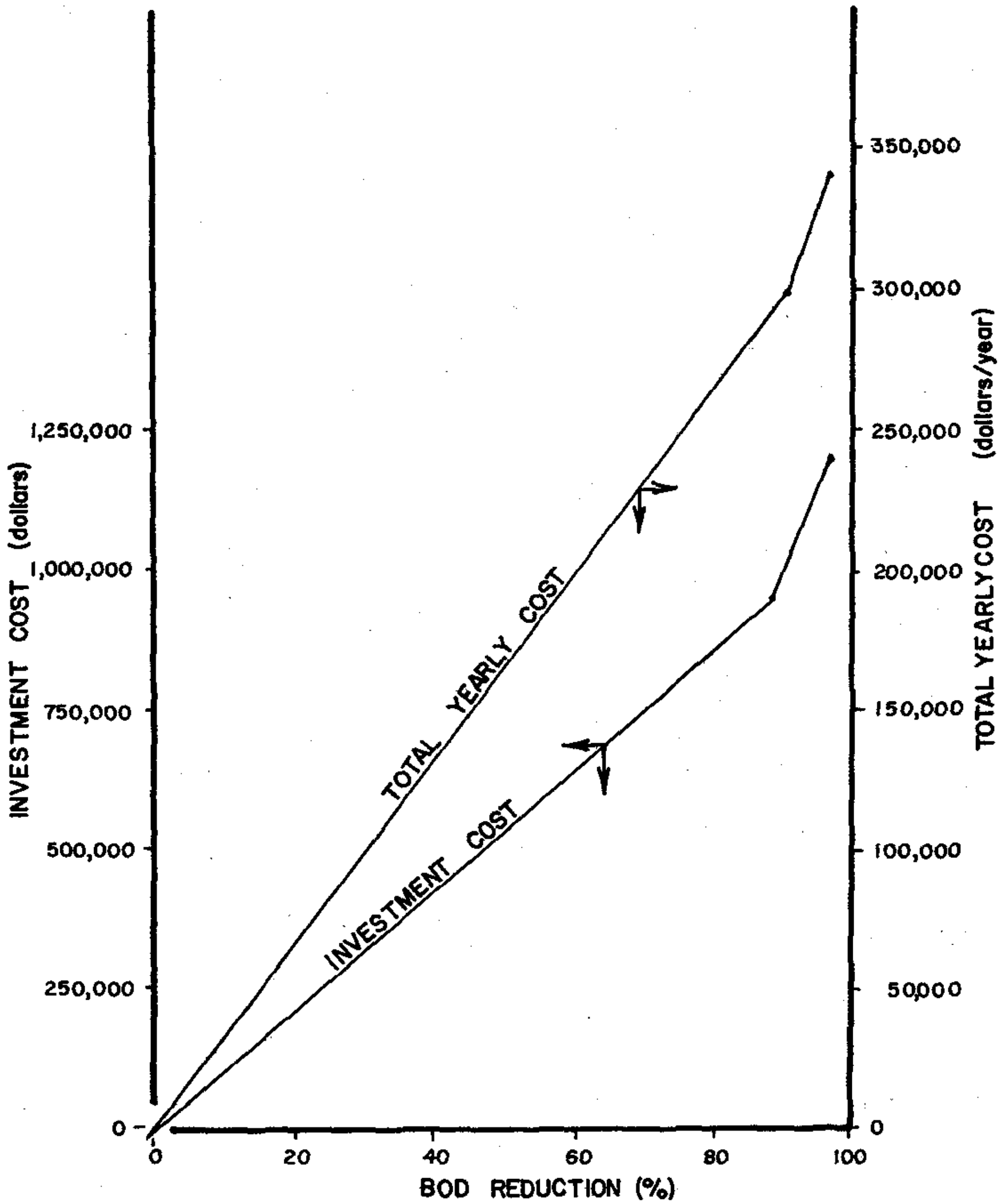


FIGURE 86 TOTAL INVESTMENT COST AND TOTAL YEARLY COST vs BOD REDUCTION FOR ALTERNATIVE C - SUBCATEGORY I OF THE INSULATION BOARD INDUSTRY

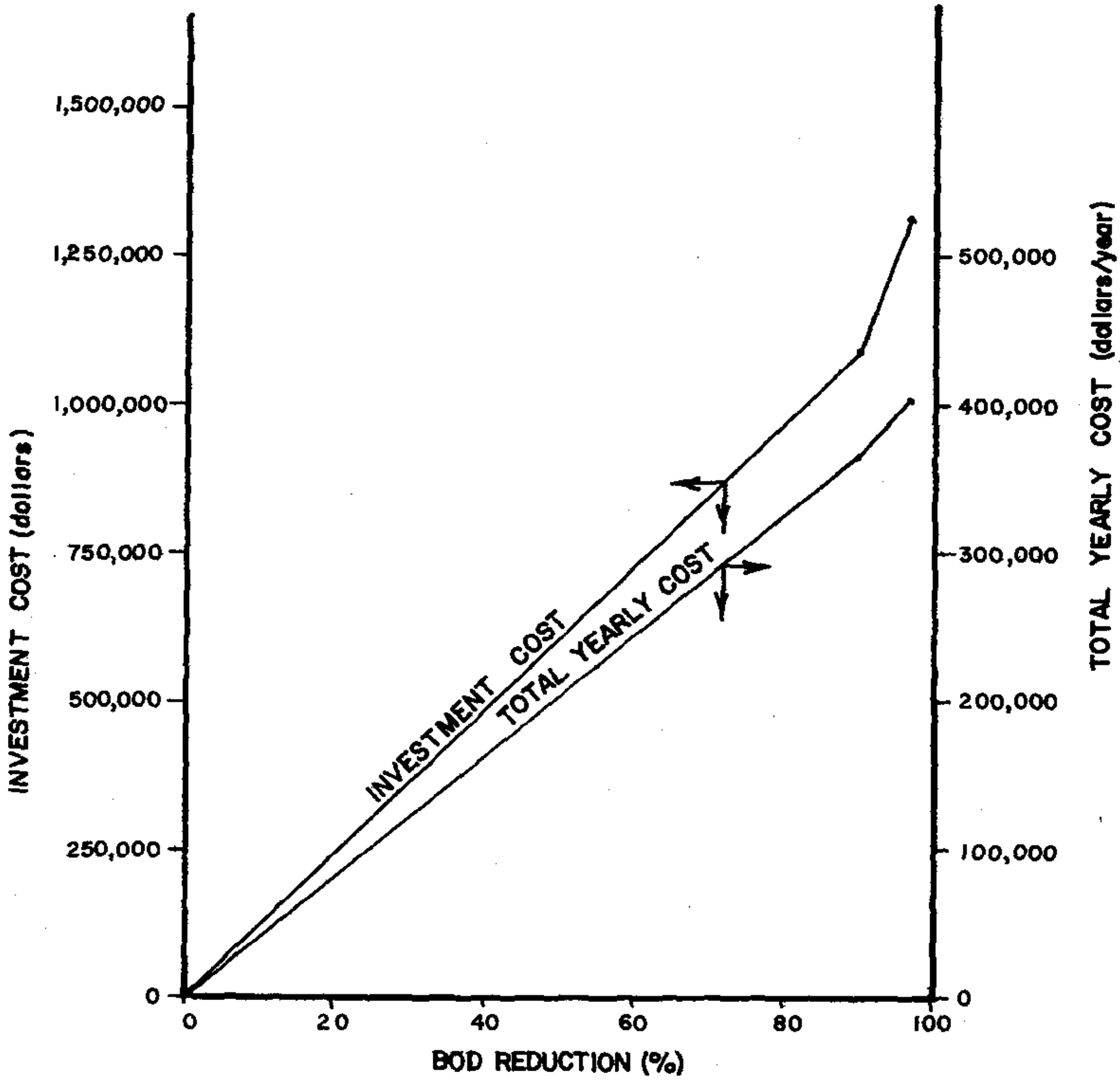


FIGURE 87 TOTAL INVESTMENT COST AND TOTAL YEARLY COST vs BOD REDUCTION FOR ALTERNATIVE C-SUBCATEGORY II OF THE INSULATION BOARD INDUSTRY

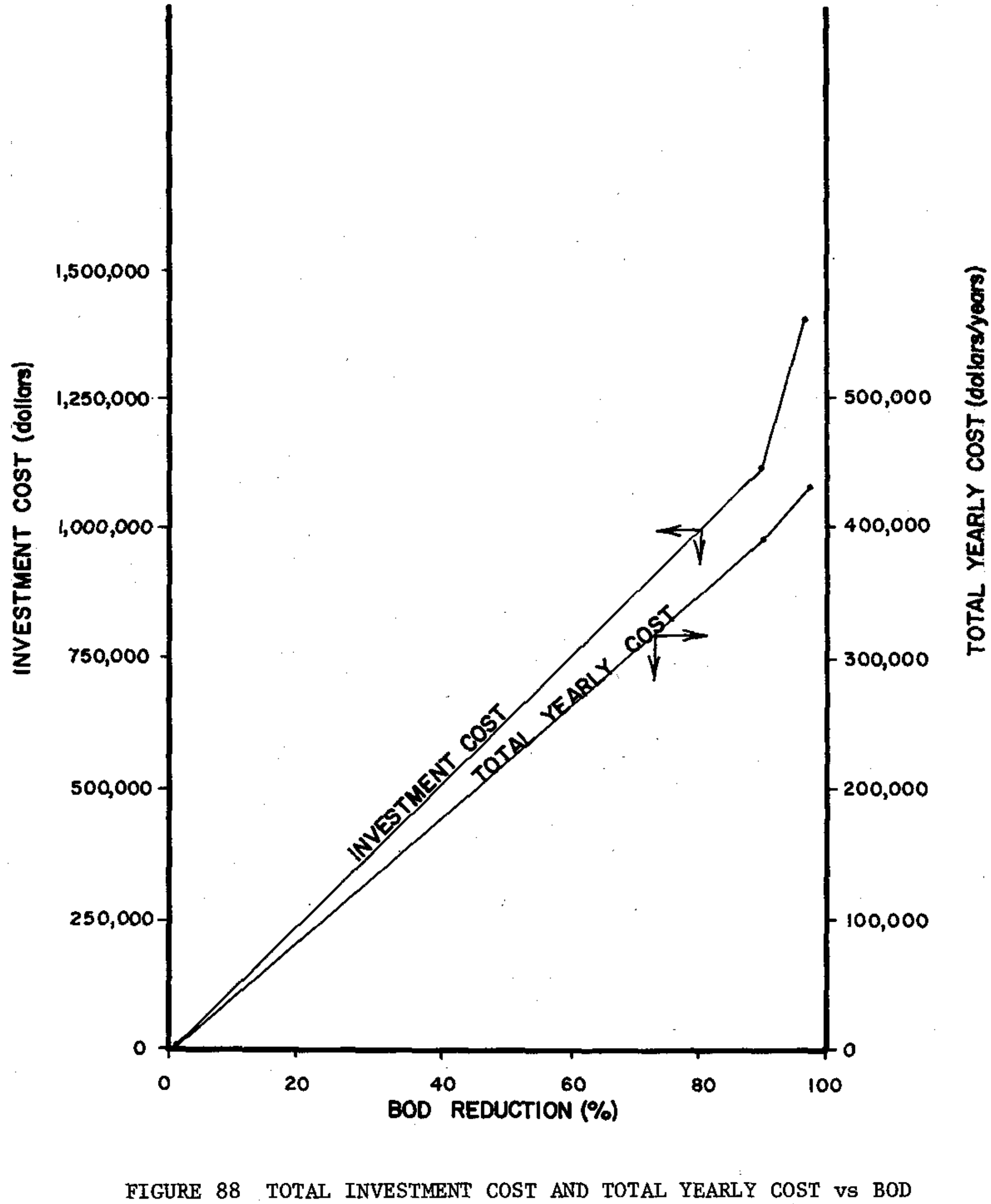


FIGURE 88 TOTAL INVESTMENT COST AND TOTAL YEARLY COST vs BOD REDUCTION FOR ALTERNATIVE C-SUBCATEGORY II OF THE INSULATION BOARD INDUSTRY

	Subcategory I	Subcategory II
Incremental Investment	$ 105,660	$ 105,660
Total Investment	1,059,800	1,266,500
Yearly Operation and Maintenance	222,800	293,900
Total Yearly Cost	$ 318,200	$ 407,900

An incremental reduction is achieved by this system resulting in a 97% overall reduction of BOD and a 91% reduction of suspended solids overall.

Cost efficiency curves for Alternative D are shown in Figures 89, 90, 91.

Alternative E - This alternative is appropriate only for plants that steam their furnish, except plant 4 and multiline mills that have either one pulping system for each production line or produce only one product. It consists of splitting the process systems at the decker. Excess machine white water is utilized to wash the fiber on the decker. The discharge from the fiber preparation system at approximately one percent dissolved solids goes to an evaporator. The concentrate from the evaporator following neutralization is pumped back into the white water system. The condensate from this system at a consistency of 30 percent is utilized for fuel for the evaporators. The excess machine white water not used in the washing operation is discharged to an activated sludge system with design parameters similar to Alternative C1 and D1 and is discharged following treatment. A detailed summary of cost is presented in Table 91. The costs of this alternative are as follows:

	Subcategory II
Initial Investment	$1,540,800
Yearly Operation and Maintenance	496,700
Total Yearly Cost	$ 635,000

A reduction of 97% in BOD and 92% in suspended solids will be achieved.

Alternative F - This alternative is applicable only for plants with large land areas available. This alternative provides spray irrigation of all plant waste waters. The system consists of a holding pond followed by a dosing pond and an irrigation field with underdrains. The cost for these units will be the same for both treatment categories, however, two systems are considered. The first is for northern climates where freezing conditions

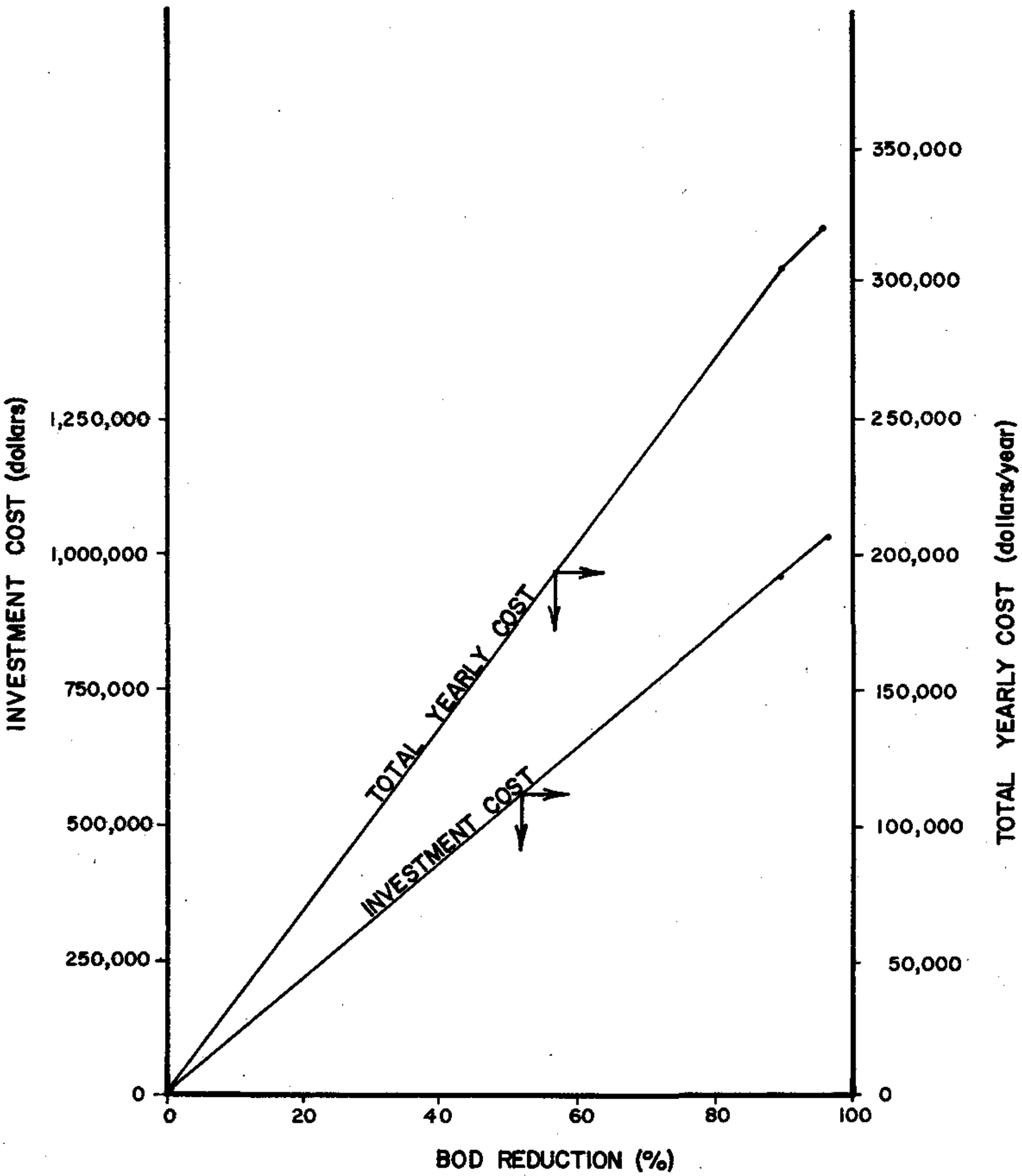


FIGURE 89 TOTAL INVESTMENT COST AND TOTAL YEARLY COST vs BOD REDUCTION FOR ALTERNATIVE D - SUBCATEGORY I OF THE INSULATION BOARD INDUSTRY

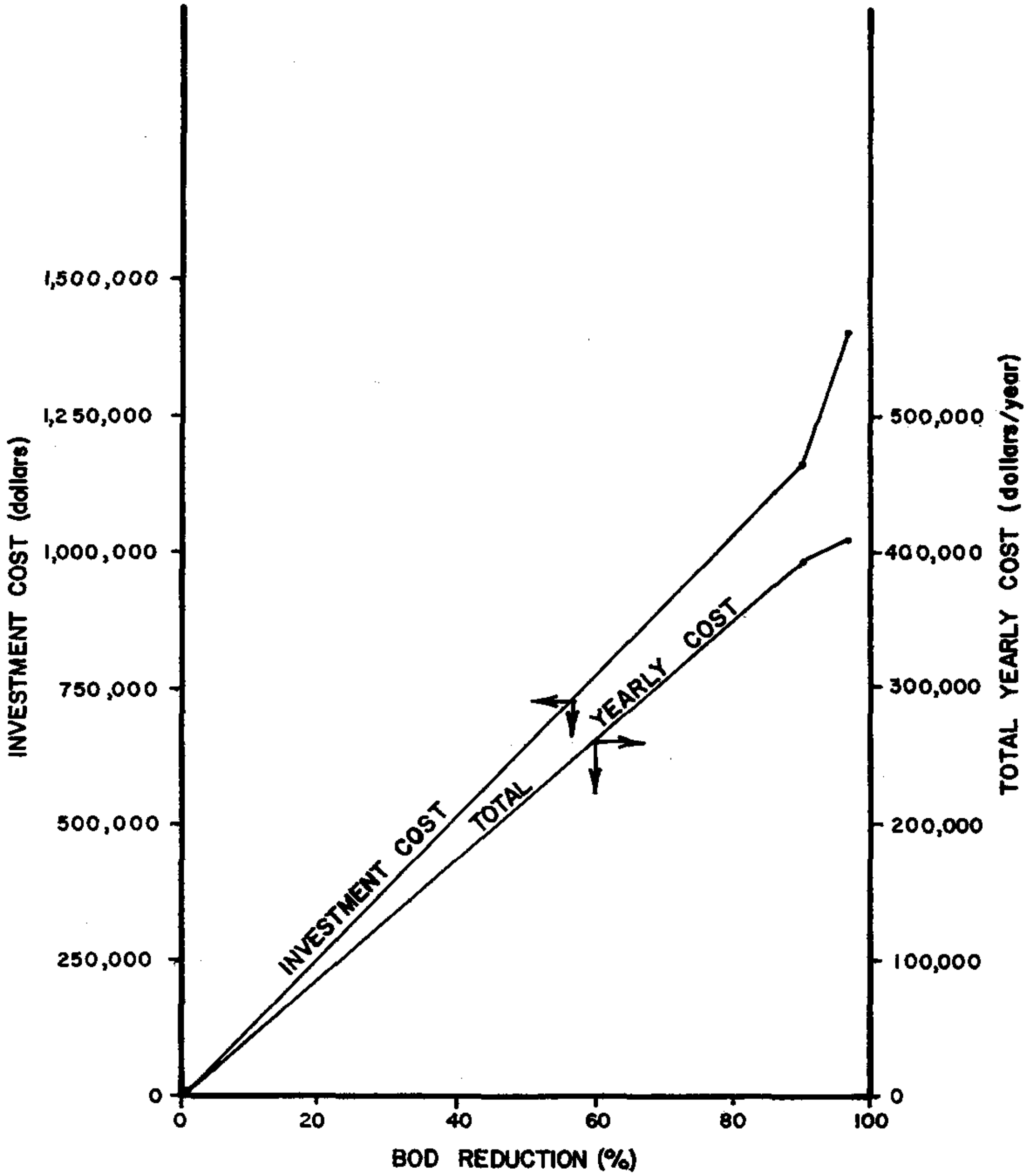


FIGURE 90 TOTAL INVESTMENT COST AND TOTAL YEARLY COST vs BOD REDUCTION FOR ALTERNATIVE D - SUBCATEGORY II OF THE INSULATION BOARD INDUSTRY

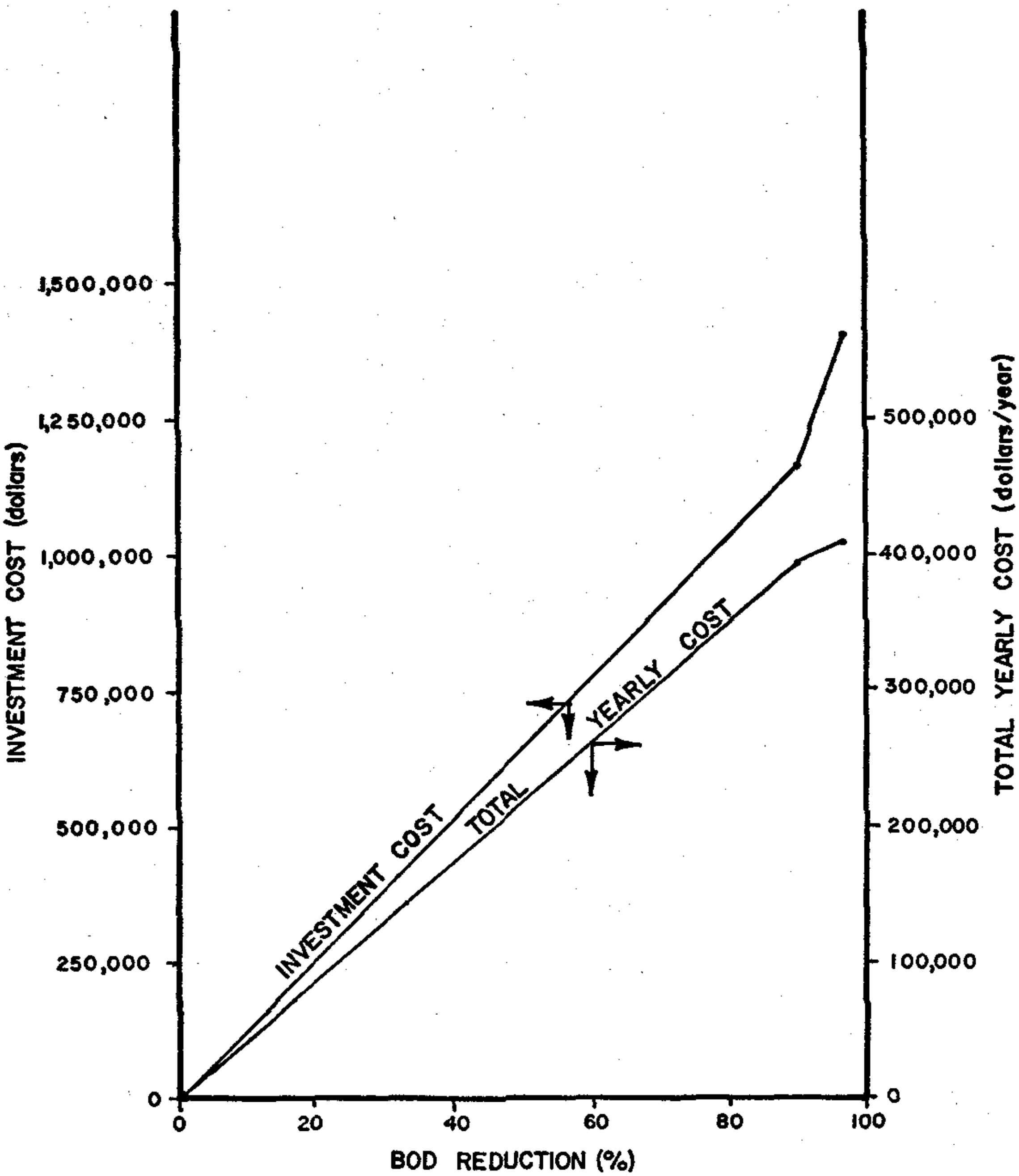


FIGURE 91 TOTAL INVESTMENT COST AND TOTAL YEARLY COST VS BOD REDUCTION FOR ALTERNATIVE D - SUBCATEGORY III OF THE INSULATION BOARD INDUSTRY

TABLE 91

ITEMIZED COST SUMMARY FOR
ALTERNATIVE E FOR INSULATION BOARD

ITEM	INVESTMENT COSTS
	Subcategory II
Evaporation:	
Evaporator	462,000-525,000
Instrumentation	46,200
Erection	186,000-210,000
Holding Tanks (2)	20,160-23,520
Pumps	8,400
Product Storage Tank	10,080-11,760
Caustic Storage	10,080-10,800
SUB-TOTAL	720,720-830,760
Activated Sludge:	
Nutrient & pH Control	7,980
Lagoon w/liner	39,312-45,360
Secondary Clarifier	59,220
Aerators	40,320-50,400
Pipes, Valves and Fittings	16,800
Electrical (Misc)	21,000

TABLE 91 (cont.)

ITEM	COST
	Subcategory II
Instrumentation	8,400
Sludge Disposal	
Thickner	31,920
Polymer Feed Equipt.	10,920
Coil Filter	111,720
Belt Conveyor	36,960
Building	37,800
SUB-TOTAL	422,352-438,480
Engineering & Contingencies	240,045-266,540
Land	5,000 (1.0 ha)
TOTAL INVESTMENT	1,387.917-1,540,840
Operation and Maintenance	
Evaporation	
Operation and Maintenance	109,620-137,050
Electricity	59,976-78,910
Steam	101,546-125,830
SUB-TOTAL	271,142-341,790

TABLE 91 (cont.)

Item	Cost
	Subcategory II
Activated Sludge	
Operation and Maintenance	125,376-127,091
Power	25,895- 27,788
SUB-TOTAL	151,271-154,879
TOTAL ALTERNATIVE E	422,413-496,669

occur. This system has a holding lagoon with a capacity of five months which allows for containment for waste water produced during the winter months when spray irrigation is not possible. The second system, designed for plants in southern climates, has a 30 day holding pond. This is necessary in the event that heavy rains eliminate the possibility of spray irrigation. Prior to the dosing pond, pH adjustments and nutrient additions may be provided. The irrigation field has underdrains to collect the treated water. A loading rate of 204,000 l/day/sq m was assumed for the spray irrigation field. A detailed summary of costs are presented in Table 92.

The costs for this alternative are as follows:

	Northern	Southern
Initial Investment	$2,009,200	$961,400
Yearly Operation and Maintenance	79,500	76,200
Total Yearly Cost	$ 260,300	$162,700

A 99% reduction of both BOD and suspended solids is achieved.

A summary of costs and reduction benefits for all alternatives is presented in Table 93.

Related Energy Requirement of Alternative Treatment and Control Technologies

Based on information contained in questionnaires provided by A.I.M.A. it is estimated that the plants for each subcategory utilize the following quantities of energy for producing 272 kkg/day of insulation board:

Subcategory	Electricity kw hr/day	Fuel Kg cal/day	Total Energy Kg cal/day
I	201,000	9.8×10^8	11.6×10^8
II	105,000-243,000	6.8×10^8-8.3×10^8	9.1×10^8-9.3×10^8

Fuel may be in the form of oil, coal, gas, or wood, A major portion of the energy required for producing insulation board is for drying the mats in the driers.

The total increase in energy requirements for each of the treatment alternatives is presented in Table 94. It should be noted for all alternatives, except E, the increase in energy is for electricity only. However, alternative E also has an increased fuel requirement for producing the steam for the

TABLE 92

ITEMIZED COST SUMMARY
FOR ALTERNATIVE F FOR INSULATION BOARD

Initial Investment Costs

Item	Costs	
	Northern	Southern
Holding Pond	26,964	26,964
Holding Basin	577,584	139,104
Pumps	24,360	24,360
Irrigation System	518,280	302,400
Control Building	4,200	4,200
Land	616,000	360,000
Engineering & Contingencies	241,790	104,376
	2,009,178	961,404
Operation and Maintenance		
Operating and Maint.	68,124	64,764
Power	11,424	11,424
	79,548	76,188

TABLE 93 SUMMARY OF COST AND BENEFITS OF TREATMENT ALTERNATIVES FOR THE MODEL INSULATION BOARD PLANT

Alternative	Subcategory	Incremental Investment Cost	Total Investment Cost	Total Yearly Operating and Maintenance Cost	Total Yearly Cost	BOD Reduction Percent	SS Reduction Percent
A	All	0	0	0	0	0	0
B	I	-	380,000	34,400	87,300	85	70
	II	-	380,000	72,400- 91,300	132,500- 155,100	85	70
C-1	I	-	954,100	216,000	302,600	90	70
	II	-	1,095,600- 1,160,800	264,100- 287,800	362,700- 392,300	90	70
C-2	I	236,500	1,190,000	235,900	343,100	97	70
	II	236,500 236,500	1,332,000- 1,397,300	283,200- 306,900	403,100- 432,700	97	70
D-1	I	-	954,100	216,700	302,600	90	70
	II	-	1,095,600- 1,160,800	264,100- 287,800	362,700- 392,300	90	70
D-2	I	105,660	1,059,800	222,800	318,200	97	91
	II	105,660 105,660	1,201,200- 1,266,500	270,200- 293,900	378,300- 407,900	97	91
E	II	- -	1,387,900- 1,540,800	422,400- 496,700	547,300- 635,400	97	92
F	Northern	-	2,009,200	79,500	260,300	99	99
	Southern	-	961,400	76,200	162,700	99	99

TABLE 94 POWER REQUIREMENTS OF TREATMENT ALTERNATIVES IN THE INSULATION BOARD INDUSTRY

Treatment Alternative	Sub-Category	Treatment Electrical Requirement (Kw-Hr/Day)	Percent increase in requirement over model plant
A	ALL	-0-	-0-
B	I	4,300	2.1
	II	9,670	9.2
		12,350	5.1
C	I	5,760	2.9
	II	11,130	10.6
		13,810	5.7
C-2	I	7,910	3.9
	II	13,280	12.6
		15,960	6.6
D-1	I	5,760	2.9
	II	11,130	10.6
		13,810	5.7
D-2	I	5,950	3.0
	II	11,320	10.8
		14,000	5.8
E	I	12,170*	6.1*
		15,130*	6.2*
F	ALL	1,620	< 1.5

*Additional non-electrical energy to heat the evaporators of 1.4×10^8 - 1.7×10^8 kg-cal is required for subcategory II. This amounts to 17-25 percent of present fuel usage.

evaporators. This amounts to between 17% and 25% of the present fuel requirement for Subcategory II.

Non-Water Quality Aspects

Alternative A assumes no additional treatment and control technologies are added to the model plant. Therefore, there are no non-water quality aspects to be considered.

Alternative B consists of adding an aerated lagoon system followed by a small settling lagoon to Alternative A. This system has all of the problems usually associated with biological treatment plus several more, including the necessity for pH control and nutrient addition. Another problem is that the biological sludge from this process does not readily settle. This can frequently cause high suspended solids in the effluent. Temperature not only has an effect on the biological reaction rates but, apparently to some extent, on the settling rates of the biological solids.

The system is sensitive to shock loads and to shut down and start up operations of the manufacturing process. The equipment needed for the aerated lagoon system is available on the market; however, up to a year or longer may be required from initiation of design until beginning of operation. The energy requirements are high. There are no noise or radiation effects associated with the process.

Alternative C1 consists of an activated sludge process. Activated sludge treatment of insulation board waste water can be quite effective. However, the system has all of the problems associated with activated sludge treatment of domestic waste plus several more. For instance, pH control and nutrient addition are required. A major problem associated with the process is that the biological solids do not readily settle. This can cause high suspended solids in the effluent. Temperature not only effects the biological reaction rates, but apparently the settling rate of the biological solids.

Activated sludge systems require constant supervision and maintenance. They are quite sensitive to shock loads and to start up and shut down operations of the manufacturing process. The equipment needed for the process is available in the market; however, up to two years may be required from initiation of design until beginning of plant operation. The energy requirements are high. There is essentially no noise or radiation effects associated with the process. Sludge is a problem and can result in odor problems.

Alternative C2 consists of the addition of an aerated lagoon to the activated sludge system. This alternative provides for an increase in treatment efficiency above that achieved by activated sludge alone. All of the problems associated with biological treatment as discussed in Alternative B and C1 apply to this Alternative C2. There is essentially no noise or radiation effects with the process. The energy requirements are high as discussed previously.

Alternative D1 is the same system as described in Alternative C1. Alternative D2 consists of the addition of mixed media filtration facilities to Alternative C1 and recycle of 70 percent of the effluent. This is done to remove the high suspended solids often found in the effluent of the activated sludge process so that the water can be recycled. This alternative has all of the problems discussed in Alternative C1 plus those associated with the operation of filtration facilities. Mixed media filtration is quite effective for removing suspended solids from the effluent of activated sludge systems; however, excessively high suspended solids concentrations can quickly blind the filter and cause high frequency of backwash. Recycle of filtered effluent is not a proven technology as the long term effects are unknown. Possible buildup of dissolved solids and increased problems of slime growths and corrosion may result.

The equipment for this process is readily available on the market. The estimated time of construction is within the two year time period allocated for the construction of the activated sludge process. The energy requirements are high as discussed previously. There is essentially no noise or radiation effects associated with the process.

Alternative E consists of the addition of two separate waste water handling systems to Alternative A. This requires that the white water system be split at the decker into fiber preparation and machine white water systems. Blowdown from the fiber preparation white water system is evaporated in a multi-effect evaporator. Condensate is reused as partial makeup for the machine white water system and concentrated waste is mixed with sander dust and burned in a boiler.

This system is applicable only in plants that steam their furnish as it is most applicable when high concentrations of dissolved solids are present from the steaming operation. This system requires either separate pulping systems for each forming machine or that the white water from multi-machine plants are compatible. The requirements of separating the white water systems may not be practical in many plants because of the high cost of plant modifications. Evaporation systems must be fed at a relatively constant rate. Maintenance requirements are high because of the nature of the material being evaporated. The evaporator must be cleaned out weekly if not more frequently. Evaporation equipment can be obtained on the market; however, a two year period from initiation of design until start up is not reasonable. Noise and radiation effects are minor, but energy requirements can be significant.

The blowdown from the machine white water system is treated in an activated sludge process. This process has the same problems associated with it as the activated sludge process discussed in

Alternative C1. Noise and radiation effects of this system are minor.

Alternative F consists of spray irrigation of all waste water from a plant. Spray irrigation of waste water depends on biological degradation of waste by soil bacteria, adsorption and ion exchange reactions within the soil, and filtration on the soil surface. These factors are greatly influenced by soil type, effluent qualities, water table, and weather conditions. Weather conditions, especially freezing temperature and high rainfall, require that provisions be made for waste water storage until such time as conditions improve. Spray irrigation fields require constant supervision and maintenance. They are sensitive to both hydraulic and organic shock loads. The pH should be controlled and nutrients added. The equipment needed for spray irrigation is available on the market; however, up to two years might be required for design and construction prior to operation. The availability of suitable sites for spray irrigation may be a limitation. There is essentially no noise or radiation effects associated with the process.

PARTICLEBOARD SUBCATEGORY

The cost estimates contained in this document are based on actual preliminary cost estimates for waste treatment systems defined in Section VII (Control and Treatment Technology) for a typical model plant defined in Section V (Water Use and Waste Characterization) of the particleboard industry. The land costs are assumed to be $1500 an acre based on the assumption that the plant is located near a small town.

The particleboard plant discharges on an intermittent basis 11,000 l (3,000 gal) per day of waste water. It has a production of 270 metric tons (300 tons) per day. The 11,000 l (3,000 gal) of waste water consist of 7,700 l (2,000 gal) per day of housekeeping water, i.e. water used for general cleanup; 1900 l (500 gal) per day of resin blender wash water; and an additional 1900 l (500 gal) per day consisting of miscellaneous flows including periodic washdown of storage tanks, pressurized refiner start-up and water from the press pit.

The plant presented here for discussion is considered to be typical of the particleboard industry at this time, However, the model plant in the future may include both a chip washer and a scrubber for air emissions control.

Cost and Reduction Benefits of Alternative Treatment and Control Technologies

Alternative A - This alternative assumes no treatment of waste water. There is no cost involved and no reduction benefits.

Alternative B - This alternative consists of screening of waste water prior to discharge to a septic tank and drain field. A detailed summary of cost is presented in Table 95.

TABLE 95

ITEMIZED COST SUMMARY
FOR ALTERNATIVE B FOR PARTICLE BOARD

Initial Investment

Item	Cost
Screens and Building	$ 6,950
Septic Tanks Drain Field	4,032
Land (0.032 ha)	117
Engineering and Contingencies	2,306
	$13,405

Operation and Maintenance

Operation and Maintenance	$ 3,528
Power	63
	$3,591

The cost of this alternative is as follows:

Initial Investment	$13,400
Yearly Operation and Maintenance	3,600
Total Yearly Cost	$ 4,800

This alternative provides for no discharge of pollutants.

Alternative C - This alternative consists of spray irrigation of all waste water. Two systems were costed because of different climatic conditions. The one for northern climates is designed with a holding pond capable of holding a five month waste flow during freezing weather. The southern climate plant was designed with the capability to hold all waste water flow during periods of heavy rainfall only. A detailed summary of costs are presented in Table 96.

The costs for this alternative are as follows:

	Northern	Southern
Initial Investment	$23,800	$16,000
Yearly Operation and Maintenance	7,000	7,400
Total Yearly Cost	$ 9,100	$ 8,800

This alternative provides for no discharge of pollutants.

Alternative D - This alternative consists of spray evaporation of all waste water. Systems were designed for four climatic regions where particleboard plants normally occur. A detailed summary of costs are presented in Table 97.

The costs for this alternative are presented below:

	SE	NE	NW	NC
Initial Investment	$22,678	$19,299	$35,023	$19.997
Yearly Operation and Maintenance	5,893	6,157	10,815	6,596
Total Yearly Cost	$ 7,934	$ 7,894	$13,967	$ 8,396

Alternative E - This alternative consists of spraying all waste water on incoming raw materials. A detailed summary of costs are presented in Table 98.

The costs for this alternative are as follows:

TABLE 96

ITEMIZED COST SUMMARY
FOR ALTERNATIVE C FOR PARTICLEBOARD

Initial Investment Costs

Item	Cost Northern	Cost Southern
Transfer Pump	$ 504	504
Spray Pump	1,512	1,260
Storage Tank	3,948	2,772
Pond	9,045	5,774
Irrigation Spray System	1,680	1,260
Land	3,600	1,950
Engineering and Contingencies	3,505	2,430
	$23,794	$15,950

Operation and Maintenance

Operation and Maintenance	6,939	7,312
Power	48	55
	$6,987	$7,367

TABLE 97

ITEMIZED COST SUMMARY
FOR ALTERNATIVE D FOR PARTICLEBOARD

Initial Investment Costs

Item	Cost			
	Southeastern	New England	Northeastern	North Central
Ponds, Control Structures, Lining	16,126	13,718	24,977	14,220
Land	3,165	2,700	4,800	2,790
Engineering & Contingencies	3,387	2,881	5,246	2,987
	$22,678	$19,299	$35,023	$19,997

Operation and Maintenance

Item	Southeastern	New England	Northeastern	North Central
Operation & Maintenance	4,093	4,185	6,870	4,459
Power	1,800	1,972	3,945	2,137
	$5,893	$6,157	$10,815	$6,596

TABLE 98

ITEMIZED COST SUMMARY
FOR ALTERNATIVE E FOR PARTICLEBOARD

Initial Investment Costs

Item	Cost
Float Activated Pump	$210
Float and Switch	168
Make-up Water Control Valve	336
Twin 5-day Detention Pits with Sump Pump and Concrete	24,066
Spray Nozzles and Piping	252
Land (.011 hec.)	41
Engineering and Contingencies	5,257
	$30,330

Operation and Maintenance

Operation and Maintenance	$3,892
Power	32
	$3,924

Initial Investment	$30,330
Yearly Operation and Maintenance	3,924
Total Yearly Cost	$ 6,654

This alternative provides for no discharge of pollutants.

Alternative F - This alternative consists of spraying all waste water on hog fuel for boiler. A detailed summary of costs are presented in Table 99.

The costs for this alternative are as follows:

Initial Investment	$20,648
Yearly Operation and Maintenance	3,940
Total Yearly Cost	$ 5,790

This alternative provides for no discharge of pollutants.

Summarized costs for all alternatives are presented in Table 100. It should be noted that all alternatives provide for no discharge of all pollutants from the manufacturing process.

Related Energy Requirements of Alternative Treatment and Control Technologies

Based on information contained in survey data provided by the National Particleboard Association, it is estimated that the model particleboard plant uses 50,000 kw hr/day of electricity to produce 300 tons/day of board. In addition, approximately 163,296 kg/day (360,000 lb/day) of steam at 15 atms. is required. The steam is usually produced with oil, gas, coal, or wood fired boilers. The model plant was estimated to use 1,416,000 l/day (50,000 cu ft/day) of gas and 51.7 kkg/day (57 tons/day) of wood and oil or coal. This, however, may vary among plants.

The total increased energy requirements for treatment alternatives are presented in Table 101. The increased energy requirements consist of only electricity and in all cases the increased electrical requirements amount to less than 1.1% of the plant's present electrical usage.

Non-Water Quality Aspects of Alternative Treatment and Control Technologies

Alternative A consists of no treatment of waste water and, therefore, there are no non-water quality aspects involved.

Alternative B consists of the use of screens, septic tanks, and drain fields. Provisions are made to pump out the septic tanks monthly and dispose of the material by land spreading. This system is one of the simplest for treating small quantities of

TABLE 99

ITEMIZED COST SUMMARY
FOR ALTERNATIVE F FOR PARTICLEBOARD

Initial Construction Costs

Item	Cost
Screens, Pump and Building	$7,160
Sump, Concrete	9,882
Land (.0073 ha)	27
Engineering and Contingencies	3,579
	$20,684

Operation and Maintenance

Operation and Maintenance	$3,877
Power	63
	$3,940

TABLE 100

SUMMARIZED COST OF TREATMENT
ALTERNATIVES FOR PARTICLEBOARD PLANTS

Alternative	Region	Initial Inves.	Operation & Maint.	Total Yrly. Cost
A	ALL	$ -0-	$ -0-	$ -0-
B	ALL	13,405	3,591	4,797
C	Northern	23,749	6,987	9,128
	Southern	15,950	7,367	8,803
D	Southeastern	22,678	5,893	7,934
	New England	19.299	6,157	7,894
	Northwestern	35,023	10,815	13,967
	North Cent.	19,997	6,596	8,396
E	ALL	30,330	3,924	6,654
F	ALL	20,648	3,940	5,798

waste. The major problem which might be experienced would be slug loads of solids that would carry through the septic tanks and plug the drain field.

The equipment necessary for this alternative is readily available. The time required from initial design to completion of construction should not exceed three months. There is essentially no noise or radiation effects associated with this process.

Alternative C consists of spray irrigation of all waste water from a particleboard plant. Spray irrigation is an effective means of waste disposal if suitable land can be found for the spray field. The volume of waste from a particleboard plant is relatively small and low loading rates should result in no discharge to navigable waters. Spray irrigation systems are influenced by weather conditions. Provisions must be made for storing waste water in northern climates during freezing conditions. Provisions must be made for waste storage in areas of heavy rainfall to prevent excess hydraulic loading of the spray field.

The equipment needed for the installation of spray irrigation fields is available on the market, however, up to one year of time may be required from start of design until completion of construction. There is essentially no noise or radiation effects associated with this process.

Alternative D consists of spray evaporation of all waste waters from the particleboard plant. Spray evaporation can be effective for disposal of small volumes of waste as experienced from the particleboard industry. Problems associated with this process are mainly associated with weather conditions. Evaporation is directly related to quantity of waste, rainfall, relative humidity, and temperature. In areas of heavy rainfall, considerably more water must be evaporated in areas of low rainfall. Freezing conditions in northern climates require excess holding capacity to be designed for winter months. Increase in suspended and dissolved solids because of evaporation will in time require solids to be removed or another evaporation pond to be installed.

The equipment needed for this process is available on the market; however, up to one year may be required from initiation of design until beginning of plant operation. There is essentially no noise or radiation effects associated with the process.

Alternative E consists of spraying all waste water on the incoming raw materials after settling of the waste. Problems associated with this process are mainly associated with the effect of the additional moisture on the raw materials. All plants may not find it feasible to spray the waste water on the raw material because of the effects of the additional moisture content on the process although several plants are presently using this system. The quantity of water to be sprayed on the

TABLE 101

POWER REQUIREMENTS OF TREATMENT ALTERNATIVES IN THE PARTICLEBOARD INDUSTRY

Treatment Alternative	Region	Treatment Electrical Requirement (kw-Hr/Day)	Percent Increase In Requirement Over Model Plant
A	ALL	-0-	-0-
B	ALL	7.5	0.02
C	Northern	6.4	0.01
	Southern	7.5	0.02
D	Southeastern	256	0.5
	New England	280	0.6
	Northwestern	559	1.1
	North Central	278	0.6
E	ALL	4.5	0.01
F	ALL	7.5	0.02

raw material is relatively small compared to the weight of the raw material; however, if the raw material is already high in moisture content the additional moisture may cause problems in the manufacturing operation.

The equipment needed for this system is readily available; however, up to six months may be required from initiation of design until start up of the process. There are essentially no noise or radiation effects associated with the process.

Alternative F consists of spraying all of the waste water on waste material utilized as fuel in a boiler. This is a feasible and effective method of disposal of small volumes of waste water. However, many plants do not burn waste material as fuel for their boiler because of air pollution problems. Therefore, this alternative depends on the existence of a hog boiler and its continued ability to meet air pollution regulations.

The equipment required for this process is readily available on the market; however, up to six months may be required from initiation of design until start up of the process. There are essentially no noise or radiation effects associated with the process.

FINISHING WITH WATER REDUCIBLE MATERIALS

The cost estimates developed herein are applicable to a finishing plant generating a volume of waste water of 750 l/day from clean up operations involved in the use of water base liquid finishing materials, as discussed in Section V. The plant produces 10 million sq m on a 6.35 mm basis (107.6 million sq ft on a 0.25 in basis) per year of prefinished paneling. It is assumed to have the following:

1. Two identical finishing lines, both operating on a 24 hour per day, seven day per week basis.

2. Each line consists of 3 water base material applicating machines.

3. Each applicating machine is washed once each day requiring 75 l (20 gal) of water/wash.

4. Material storage and mixing vats require a total of 300 l (80 gal) of washwater/day.

5. Total waste water generated is 750 lpd (200 gal/day) and will occur 365 days/year.

The typical plant was selected on the basis of the volume of waste water generated. Volumes of waste water generated from finishing operations range from 75 lpd (20 gal/day) to 1,100 l/day (300 gal/day) as pointed out in a previous section. Therefore, a total volume of 750 l/day (200 gal/day) can be assumed to be a typical value.

Cost and Reduction Benefits of Alternative Treatment and Control Technology

The recommended alternative treatment methods for this subcategory are similar to Alternatives B, C, D, and F for Model 1 for fabricating with the exception that screening of the waste water is not required. The revised summaries of costs of treatment for the applicable alternatives are presented below. Detailed cost estimates for each alternative are the same as those presented for the fabrication subcategory without screening.

Alternative A - This alternative consists of no control and treatment. No costs are associated with this alternative nor are any reduction benefits achieved.

Alternative B - This alternative consists of a spray evaporation pond as described for fabrication.

The Costs of Control and Treatment are as follows:

Total Investment Costs	$24,100
Total Yearly Operating and Maintenance	1,700
Total Yearly Costs	$ 3,800

100 percent reduction of pollutants is achieved.

Alternative C - This alternative consists of discharge to a holding tank followed by spraying on hogged fuel prior to burning.

The costs of control and treatment are as follows:

Total Investment Costs	$6,200
Total Yearly Operating and Maintenance	3,200
Total Yearly Costs	$3,700

100 percent reduction is achieved.

Alternative D - This alternative consists of discharge to a holding tank followed by trucking to land spreading.

The costs of control and treatment are as follows:

Total Investment Costs	$7,100
Total Yearly Operating and Maintenance	1,600

Total Yearly Costs	$2,200

100 percent reduction is achieved.

Alternative F - This alternative consists of discharge to a municipal sewer.

The costs of control and treatment are as follows:

Total Yearly Operating and Maintenance	$ 300
Total Yearly Costs	$ 300

100 percent reduction is achieved.

A summary of alternative costs for treatment of waste waters from this subcategory is presented in Table 102.

Related Energy Requirements of Alternative Treatment and Control Technology

The industries represented by this subcategory are extremely diverse in terms of product produced and energy consumed. Therefore, no information is available which is representative of energy requirements for finishing operations.

The costs presented in Table 103 are the anticipated annual energy costs for the alternative treatment and control technologies.

Non-Water Quality Aspects of Alternative Treatment and Control Technologies

The non-water quality aspects of the various alternatives are anticipated to be negligible. However, disposal of wastes by landspreading must be carefully controlled to prevent groundwater and surface water contamination. There are no air pollution, noise, or radiation effects from the installation of any of the above systems.

TABLE 102

SUMMARY OF ALTERNATIVE COSTS
FOR FINISHING WITH WATER REDUCIBLE MATERIALS

Alternative	Percent Reduction	Investment Costs	Total Yrly. Operating Costs	Total Yrly. Costs
A	-0-	-0-	-0-	-0-
B	100	$24,100	$1,700	$3,800
C	100	$ 6,200	$3,200	$3,700
D	100	$ 7,100	$1,600	$2,200
E		Not Applicable		
F	100	-0-	$ 300	$ 300

TABLE 103

ANTICIPATED ANNUAL ENERGY COSTS FOR ALTERNATE CONTROL TECHNOLOGIES FOR FINISHING WITH WATER REDUCIBLE MATERIALS

Alternative	Model-1 Costs
A	-0-
B	$144
C	$ 20
D	$ 20
E	Not Applicable
F	-0-

SECTION IX

BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

INTRODUCTION

The effluent limitations which must be achieved by July 1, 1977 are to specify the degree of effluent reduction attainable through the application of the Best Practicable Control Technology Currently Available. Best Practicable Control Technology Currently Available is generally based upon the average of best existing performance by plants of various sizes, ages, and unit processes within the industrial category or subcategory. This average is not based on a broad range of performance with the timber products processing subcategory but rather based on levels of performance achieved by exemplary plants.

Consideration must also be given to:

a. The total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application;

b. The size and age of equipment and facilities involved;

c. The process employed;

d. The engineering aspects of the application of various types of control techniques;

e. Process changes;

f. Non-water quality environmental impact (including energy requirements); and

g. Availability of land for use in waste water treatment disposal.

Best Practicable Control Technology Currently Available emphasizes treatment facilities at the end of a manufacturing process but also includes the control technologies within the process itself when these are considered to be normal practice within the industry.

A further consideration in the determination of BPCT is the degree of economic and engineering reliability which must be established for the technology to be considered "currently available." As a result of demonstration projects, pilot plants, and general use, there must exist a high degree of confidence in the engineering and economic practicability of the technology at the time of construction or installation of the control facilities.

In addition to the above factors, consideration should be given to plants or unit processes that form parts of industrial complexes. Such complexes may be composed of various combinations of some or all of the subcategories discussed herein, as well as operations such as pulp and paper production, furniture manufacturing, or other processes not covered in this study. While a numerical addition of pollutant loads from all unit operations will yield the total effluent load from a complex, several factors may affect the application of available control and treatment technology. In treatment of its total waste water discharge the complex may have the advantages of economies of scale, improved potential for water recycle, and joint use of a unit process. It may also have the disadvantages of lack of available land, substantial previous investments in control and treatment technology that may not be applicable to the proposed guidelines, alteration of waste water treatability as a result of the combining of waste streams, or, if waste must be treated separately, the additional expense of segregation of the combined waste streams. The effluent guidelines and standards presented below reflect consideration of these factors.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE FOR WET STORAGE

Based on the information contained in Sections III through VIII of this document, it has been determined that the application of the best practicable control technology for wet storage operations results from the control of the discharge from pond storage situations during periods when precipitation is less than evaporation. Control of the volume discharged from a wet decking operation is achieved by process management. When a discharge is allowed from a wet storage facility a particle size limit, maximum size 2.54 cm (1.0 in.) diameter, is proposed, in addition to a pH range limitation.

Identification of Best Practicable Control Technology Currently Available

The technology identified as the best practicable control technology currently available involves the reasonable control of the discharge of extraneous process waters into the wet storage pond or recycle pond serving a wet deck. Appropriate control technology may possibly involve the relocation of the discharge point of the pond away from activity points on the pond. Activity points include points where logs are deposited in the pond, the location where logs are taken to the processing plant, areas where pond boats have activity stirs up the pond bottom. In ponds where saws are used to trim log ends, sawdust and bark materials can be relatively easily kept out of the pond by utilizing water jets to force the waste material into a specific location where it either settles and sinks for removal from the pond waters or forced out the water to be shoveled out and disposed.

The utilization of various types of discharge systems will help to achieve limitations on debris. Common practice in the industry is the use of a floating boom to retain floating materials within the body of water. Also submerged weirs are utilized to retain floating materials. Another mechanism that may be effective is the inverted outlet. This involves placing an inverted drum over a discharge pipe. Floating materials cannot reach the discharge pipe unless it passes underneath the edge of the drum.

Engineering Aspects of Control Technology Applications

Treatment and control technology as it currently exists for the wet storage subcategory involves, in most cases, the application of relatively uncomplicated technology. The proposed guidelines and standards can be achieved by the use of floating booms, submerged weirs, inverted or submerged discharges, and/or a quiescent area before discharge.

Cost of Application

The total investment costs for the treatment and control scheme for the wet storage subcategory are estimated to be less than $3,000 for a pond storage facility and slightly more for a wet decking operation. It should be kept in mind that these costs are maximum costs and that a significant percentage of the facilities that will be covered by these regulations are either already achieving these limitations or can achieve them with either a modification of operating procedures or a minimal amount of expense.

Non-Water Quality Environmental Impact

The non-water quality environmental impact will be relatively minor for the application of Best Practical Control Technology Currently Available. No air pollutants will be produced. The solid wastes will be landfilled. The varying water levels in the ponds may, at the end of the dry season, expose aesthetically displeasing mud or sludge deposits. However, the pond can have a pleasing appearance if maintained properly.

Factors to be Considered in Applying Effluent Limitations

The proposed guidelines and standards for wet storage operations are based in part on the consideration that reasonable water use is practiced in the manufacturing operation that makes use of the wet storage facility. The volume limitation on discharge from a wet storage facility, particularly a pond, cannot be achieved if control is not maintained over the volume of process water discharged to the wet storage water system. Although there is not a specific or absolute limitation on the amount or sources of water going into the system, it is recognized that some process waters, such as glue system water, binder washing water, process waters containing oil and grease, and other process waters may contain pollutants which if they come in contact with navigable waters, will have an adverse effect on water quality.

The diversion of extraneous influents from surface runoff is a consideration also. While it is not possible to develop the costs associated with diversion because it is so geographical and climatic dependent, diversion should be considered as a tool available to achieve the minimization of the discharge of pollutants.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE FOR THE LOG WASHING SUBCATEGORY

Based on the information contained in Sections III through VIII of this document, it has been determined that the application of the Best Practicable Control Technology Currently Available is that resulting from recycle of the log wash effluent. The effluent levels obtainable for this degree of waste water reduction is no discharge of process waste water pollutants to navigable waters.

Identification of Best Practicable Control Technology Currently Available

The best practicable technology currently available consists of screening the log wash effluent followed by sedimentation to remove grit and suspended solids and screening preceding recycle of the effluent to the log washing operation.

Recycle of log wash effluent is considered currently available practicable technology since total recycle is being accomplished by at least two sawmills. The technology for total recycle is uncomplicated in nature and should be achievable by July 1, 1977.

Costs of Application

The costs of attaining the recommended effluent reductions set forth herein are presented in Section VIII, Cost, Energy, and Non-Water Quality Aspects and are summarized below.

Costs of Treatment and Control:

Incremental Investment Costs:	$27,600
Total Investment Costs:	$27,600
Total Yearly Operating Costs:	$14,700
Total Yearly Costs:	$17,200

Non-Water Quality Environmental Impact

The non-water quality environmental impact of the application of a closed system for a log washing operation may be considered to be negligible. There is no appreciable increase in energy consumption for log washing with the application of the recommended technology. The material removed from the logs, primarily inorganic in nature, will vary in amount, depending on the conditions of harvesting and transportation. The disposal of this material by landfill should not have an adverse impact on the environment.

Factors to be Considered in Applying Effluent Limitations

No discharge of pollutants should be attainable for all operations specifically designed to wash logs. This limitation is not intended for application to operations such as hydraulic debarking and wet storage wherein log washing may occur incidentally.

It should be noted that the no discharge limitation and the costs associated with the application of this limitation were predicated on the assumption that extensive changes in the mill feed will not be required.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE FOR THE SAWMILL AND PLANING MILL SUBCATEGORY

Based on the information contained in Sections III through VIII of this document, it has been determined that the application of the Best Practicable Control Technology Currently Available is that resulting from proper inplant management and control. The effluent level obtainable by the application of this no discharge of waste water pollutants to navigable waters.

Identification of Best Practicable Control Technology Currently Available

The Best Practicable Control Technology Currently Available consists of the application of inplant management practices as discussed in Section VII, Control and Treatment Technology. These included management of water use, prevention of the contamination of non-contact cooling water.

Engineering Aspects of Control Technology Applications

The inplant control measures recommended for sawmills and planing mills are currently practicable in that all have been observed at various mills.

Costs of Application

As stated in Section VIII, the cost of achieving no discharge in sawmills and planing mills as defined in this document is considered to be negligible.

Non-Water Quality Environmental Impact

There are no known non-water quality aspects involved in the application of a no discharge limitation.

Factors to be Considered in Applying Effluent Limitations

The pertinent factors to be considered in applying effluent limitation to sawmills and planing mills is the definition of a sawmill. In other words, by definition the sawmill does not include raw material storage or handling, log washing, debarking, power or steam generation or fabricating and finishing operations. Thus, the effluent limitation of zero discharge for sawmills and planing mills is only applicable to the manufacture of lumber from debarked logs.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE FOR THE FINISHING SUBCATEGORY

Based on the information contained in Sections III through VIII of this document, it has been determined that the application of the Best Practicable Control Technology Currently Available is evaporation, incineration, land spreading or recycle of process washwaters for reuse as washwater or makeup water. The effluent level obtainable by the application of this technology is no discharge of process waste water pollutants.

Identification of Best Practicable Control Technology Currently Available

The best practicable control technology currently available consists of one or more of the following alternatives:

1. Evaporation by the use of spray evaporators.
2. Trucking to landspreading.
3. Incineration by spraying of hogged fuel prior to burning.
4. Recycle of glue system water

Engineering Aspects of Control Technique Applications

Recycle of glue washwater for reuse as washwater is a currently practicable technology in the plywood industry. It has been observed in at least four U. S. plywood plants and has been reported by Haskell to be utilized in a European plywood mill. The feasibility for transfer of this technology to the water soluble glue using segment of the finishing subcategory has been recognized by representatives from government and industry. It should be noted, however, that the finishing subcategory contains a wide variety of plants using a wide variety of glue applicators and various types of glues. Therefore, the recycle of washwater may not be practicable in all cases. Limitations on recycle may exist for certain types of resins although there is presently no information available to substantiate any such limitation. These and other aspects will influence the determination of a treatment alternative but should not affect the attainment of a zero discharge limitation. All of the recommended alternatives are practicable since all have been observed at various finishing plants utilizing water reducible finishing materials.

Costs of Application

The investment costs of achieving the proposed guidelines and standards range between $0 and $27,000 with a range of operating costs between $300 and $3200.

Non-Water Quality Environmental Impact

Because of the relatively small volumes of waste water associated with this subcategory the non-water quality aspects including energy consumption of the various alternatives were assumed to be negligible in Section VIII. However, as all the recommended alternatives result in no discharge to pollutants, the best practicable technology is that technology which most significantly reduces the potential for environmental impact. Recycle of washwater for reuse as washwater accomplishes no discharge of pollutants while not increasing the potential for air pollution as may be the case with incineration, without increasing the potential for groundwater pollution as may be the case with evaporation ponds, without increasing the potential for surface water contamination as may be the case with land spreading, and with the least energy consumption of all the recommended alternatives other than discharge to municipal sewers.

Factors to be Considered in Applying Effluent Limitations

The no discharge limitation for the finishing subcategory utilizing water soluble adhesives is considered to be attainable in all cases. However, since there are a wide variety of types of mills utilizing a variety of water soluble adhesives and various types of applicators, there may exist limitations on the adoption of recycle as a control technique. In those cases where recycle of washwater for reuse as washwater may be demonstrated to not be a practicable technology one of the following alternatives will be applicable:

1. Incineration via spraying the glue wastes on hogged fuel prior to burning.
2. Disposal by controlled land spreading.
3. Discharge to municipal sewer.
4. Evaporation

The factors which may contribute to the necessity for adopting one of the above alternatives may be:

1. Impracticality of collecting several small waste streams for where these streams are

currently discharged separately to a municipal sewer.

2. A particular type of adhesive may not lend itself to extended recycling because of deterioration of resin solids or buildup of dissolved solids.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE FOR THE INSULATION BOARD SUBCATEGORIES

Based on the information contained in Sections III through VIII of this document, a determination has been made that the degree of effluent reduction attainable and maximum allowable discharge in the insulation board industry, based on the application of the best practicable control technology currently available is set forth in the following table.

30-Day Average

Subcategory	BOD5		Total Suspended Solids		pH
	kg/kkg	lb/ton	kg/kkg	lb/ton	--
I	1.25	2.50	3.13	6.25	6-9
II	3.75	7.50	3.13	6.25	6-9

Daily Maximum

Subcategory	BOD5		Total Suspended Solids		pH
	kg/kkg	lb/ton	kg/kkg	lb/ton	--
I	3.75	7.50	9.40	18.8	6-9
II	11.3	22.6	9.40	18.8	6-9

Identification of Best Practicable Control Technology Currently Available

Insulation board is manufactured in a manner discussed in detail in Section III. The wastes are derived and characterized in Section V and treatment and control technologies in Section VII. The Best Practicable Control Technology Currently Available is treatment of the total waste water discharge by biological treatment possibly with pH adjustment and nutrient addition prior to the biological treatment process. Disposal of waste sludge is by drum filtration followed by disposal of the dewatered sludge.

Engineering Aspects of Control Techniques Applicable

The levels of technology summarized above and the effluent reductions suggested are currently obtained by plants in both subcategories. Information obtained from 16 insulation board plants indicated a typical waste water discharge of 54,250 l/kkg (3,000 gal per ton) for all subcategories. Raw waste water characteristics of the model plant are 10 kg/kkg (20 pounds per ton) of suspended solids for all categories and BOD loads as follows: Category I, 12.5 kg/kkg (25 pounds per ton); and Category II, 37.5 kg/kkg (75 pounds per ton). The treatment and control technology summarized above is in use in at least one manufacturing plant of each subcategory of the insulation board industry, and each has demonstrated a high degree of engineering reliability.

The equipment needed for the process is available on the market; however, up to two years may be required from initiation of design until beginning of plant operation. Once plant operation is initiated there will be at least a six-week start-up period required for process stabilization.

There are no significant process changes required. The addition of certain capabilities and implementation of water recycle and conservation practices will be needed to meet these limitations.

Cost of Application

The cost of obtaining the recommended effluent limitations set forth herein for the model plants are presented in Section VIII, Cost, Energy and Non-Water Quality Aspects and summarized below:

Subcategory	Investment	Yearly	% Increase in Capital Cost of New Plant (12.6 Million)
I	$ 954,100	$302,600	7.6
II	1,095,600- 1,160,800	362,700- 392,300	8.7- 9.2

Non-Water Quality Environmental Impact

The implementation of the above treatment technologies as discussed in Section VIII relys on the ultimate disposal of the waste activated sludge on the land. The energy requirement as presented in Section VIII will account for less than 11 percent of the present electrical requirement of the model plants of all subcategories.

Factors to be Considered in Applying Effluent Limitations

As discussed in Section VIII, activated sludge systems are sensitive to shock loads resulting from start-up or process malfunctions. Systems of this type require trained operating personnel to achieve optimum treatment efficiency. It should be noted that there are certain limitations on the efficiency of biological waste water systems in northern climates where freezing conditions occur. Upset conditions resulting from any of the above reasons may result in an increase in the amount of suspended solids being discharged.

During the start-up period the waste water effluent from the treatment system may exhibit large variations in both BOD and suspended solid discharges.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE FOR THE PARTICLEBOARD SUBCATEGORY

Based on the information contained in Sections III through VIII of this Document, it has been determined that the effluent level obtainable for particleboard manufacture by the application of the Best Practicable Control Technology Currently Available is no discharge of process waste water pollutants. This does not apply to uncontaminated cooling water, roof and yard runoff, and waters resulting from the handling and storage of raw materials.

Identification of Best Practicable Control Technology Currently Available

Particleboard is manufactured in a manner discussed in detail in Section III. The waste derived and characterized in Section V and treatment and control technologies in Section VII. The best practical control technology currently available which will result in elimination of the discharge of pollutants requires the implementation of one of one of the following:

1. Screening the total waste water flow prior to discharge to a septic tank and drain field.
2. Spray irrigation of the waste water.
3. The evaporation of all waste water in a spray evaporation pond.
4. Spraying all waste water on incoming raw material.
5. Spraying all waste water on hog fuel.

Engineering Aspects of Control Technologies Applicable

The application of the technologies summarized above and the effluent reductions suggested are reported to be obtained by 13 plants. Each of the treatment technologies listed above are currently in use in at least one particleboard plant (or in the case of spray evaporation, a plant with similar waste water generation) and each has demonstrated a high degree of engineering reliability. There are no process changes necessary for the implementation of the above technologies, although some plants may have to segregate non-contact cooling waters from the waste water streams and modify their boilers to accept hog fuel.

Cost of Application

The costs of obtaining the recommended effluent reductions set forth herein for the model plant, are presented in Section VIII, Cost, Energy, and Non-Water Quality Aspects. The cost will vary by choice of treatment system and in some cases the climatic conditions occurring at the plant's location. The total yearly costs range from $4,800 to $14,000 with 90% less than $10,000. The capital investment costs range from $13,400 to $35,000 which represents 0.16 to 0.42 percent of the $8.4 million cost of constructing a new 270 metric ton/day (300 ton/day) plant.

Non-Water Quality Environmental Impact

The non-water quality impact will result from the land disposal of small amounts of sludge from certain alternatives. The impact, however, will be insignificant because of the relatively small quantities of solid material to be treated.

As presented in Section VIII the required energy for each alternative treatment system will cause an increase of less than 1.1% in the electrical requirements of the model plant.

Factors to be Considered in Applying Effluent Limitations

As presented in Section V, Water Use and Waste Characteristics, the model plant does not have a wet scrubber for air emission control nor does it have a chip washer. Presently a minority of existing plants have wet scrubbers in use and one plant is reported to use a chip washer. The use of either of these devices may result in an additional waste water source and thus affect the costs of treatment.

SECTION X

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

INTRODUCTION

The effluent limitations which must be achieved by July 1, 1983, are to specify the degree of effluent reduction attainable through the application of the best available technology economically achievable. The best available technology economically achievable is not based on an average of the best performance within an industrial category, but is to be determined by identifying the very best control and treatment technology employed by a specific point source within the industrial category, or subcategory, or the application of different technology it is transferable from one industry to another with a reasonable degree of confidence. A specific finding must be made as to the availability of control measures and practices to eliminate the discharge of pollutants, taking into account the cost of such elimination.

Consideration must also be given to:

(a) the age of equipment and facilities involved;
(b) the process employed;
(c) the engineering aspects of the application of various types of control techniques;
(d) process changes;
(e) cost of achieving the effluent reduction;
(f) non-water quality environmental impact (including energy requirements).

In contrast to the best practicable control technology currently available, the best economically achievable technology assesses the availability in all cases of in-process controls as well as additional treatment techniques employed at the end of a production process.

Those plant processes and control technologies which at the pilot plant, semi-works, or other levels, have demonstrated both technological performances and economic viability at a level sufficient to reasonably justify investing in such facilities may be considered in determining the best available technology economically achievable. The best available technology economically achievable is the highest degree of technology that has been achieved or has been demonstrated to be capable of being applied to plant scale operation up to and including "no discharge" of pollutants. Although economic factors are considered in this development, the costs for this level of control are intended to be the top-of-the-line of current technology subject to limitations imposed by economic and engineering feasibility considerations. However, the best available technology economically achievable may be characterized by some technical risk with respect to performance and with respect to certainty of costs. Therefore, the best available technology economically achievable may necessitate some industrially sponsored development work prior to its application.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE FOR THE WET STORAGE SUBCATEGORY

Based on the information contained in Sections III through VIII of this document, best available technology economically achievable is the same as that identified as best practicable control technology currently available in Section IX of this report.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE EFFLUENT LIMITATIONS GUIDELINES FOR THE LOG WASHING SUBCATEGORY

The effluent limitation reflecting this technology is no discharge of waste water pollutants navigable waters as developed in Section IX.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE EFFLUENT LIMITATIONS GUIDELINES FOR THE SAWMILL AND PLANING MILL SUBCATEGORY

The effluent limitation reflecting this technology is no discharge of waste water pollutants navigable waters as developed in Section IX.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE GUIDELINES FOR THE FINISHING SUBCATEGORY

The effluent limitation reflecting this technology is no discharge of process waste water pollutants to navigable waters as developed in Section IX.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE FOR THE PARTICLEBOARD SUBCATEGORY

The effluent limitation achievable by the application of best available control technology economically achievable is no discharge of pollutants as discussed in Section IX.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE FOR THE INSULATION BOARD SUBCATEGORIES

Based on the information contained in Sections III through VIII of this document, a determination has been made that the effluent limitation representing the degree of effluent reduction attainable in the insulation board subcategories through the application of the best available technology economically achievable is a maximum discharge as follows:

30-Day Average

Subcategory	BOD5		Total Suspended Solids		pH
	kg/kkg	lb/ton	kg/kkg	lb/ton	--
I	0.38	0.75	0.85	1.9	6-9
II	1.13	2.35	0.85	2.9	6-9

Daily Maximum

Subcategory	BOD5		Total Suspended Solids		pH
	kg/kkg	lb/ton	kg/kkg	lb/ton	--
I	1.13	2.25	2.85	5.70	6-9
II	3.38	6.75	2.85	5.70	6-9

Identification of the Best Available Technology Economically Achievable

The best available technology economically achievable in the insulation board industry is based on the treatment of all waste water in a biological treatment system and recycling 70 percent of the flow after mixed media filtration as described in Section VII. The remaining 30 percent of the flow is discharged with no further treatment after the activated sludge system.

Engineering Aspects of Control Techniques Applicable

The technology summarized above is currently being utilized on an experimental basis by two plants in subcategory I and one plant in subcategory II. There is no information available on the possible long term effects of reusing secondary effluent as process makeup water; however, representatives of the insulation board industry indicate that the reuse of a portion of the secondary effluent from an activated sludge process is probably feasible. The initiation of this technology will have to be accomplished gradually to determine the effect on the production process.

Cost of Application

The cost of obtaining the recommended effluent reductions set forth herein, for the model plants, are presented in Section VIII, Cost, Energy, and Non-Water Quality Aspects and are summarized below:

Subcategory	Total Investment Cost	Total Yearly Cost	% Capital of New Plant (12.6 million)
I	$1,059,800	$318,200	8.4
II	1,201,200- 1,266,500	378,300- 407,900	9.5- 10.0

Non-Water Quality Environmental Impact The increase in energy required for the implementation of this technology is presented in detail in Section VIII. The energy required is electrical and represents less than an 11 percent increase in the electricity requirements of the model plants. As discussed in Section VIII the non-water quality impact of this technology relates to the land disposal of the solids removed from the waste water by filtration. This is in addition to the waste solids resulting from the activated sludge system as summarized in Section IX.

Factors to be Considered in Applying Effluent Limitations

Operational limitations of the activated sludge process should be considered in the application of the above effluent limitations. These operational constraints are discussed under Section VIII and summarized in Section IX. In addition, the technology required to achieve the best available technology economically achievable effluent limitations relies on the recycle of 70 percent of the effluent from an activated sludge system. It is conceivable that all plants may not be able to recycle as much as 70 percent of the secondary effluent or, on the other hand, that some plants may be able to recycle more than 70 percent. This will be dependent on the individual plant's production process.

There are currently three plants in subcategory II achieving this level of effluent reduction by the use of spray irrigation. However, this technology cannot be utilized be every plant within the industry as large areas of suitable land are required.

SECTION XI

NEW SOURCE PERFORMANCE STANDARDS

INTRODUCTION

This level of technology is to be achieved by new sources. The term "new source" is defined in the Act to mean "any source, the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance." New source technology shall be evaluated by adding to the consideration underlying the identification of best available technology economically achievable a determination of what higher levels of pollution control are available through the use of improved production processes and/or treatment techniques. In addition to considering the best in-plant and end-of-process control technology, identified in best available technology economically achievable, new source technology is to be based on an analysis of how the level of effluent may be reduced by changing the production process itself. Alternative processes, operating methods or other alternatives must be considered. However, the end result of the analysis will be to identify effluent standards which reflect levels of control achievable through the use of improved production processes (as well as control technology), rather than prescribing a particular type of process or technology which must be employed. A further determination which must be made for new source technology is whether a standard permitting no discharge of pollutants is practicable.

Specific factors to be considered in the determination of standards of performance for new sources:

- (a) the process employed and possible process changes;
- (b) operating methods;
- (c) batch as opposed to continuous operations;
- (d) use of alternative raw materials and mixes of raw materials;
- (e) use of dry rather than wet processes (including substitution of recoverable solvents for water); and
- (f) recovery of pollutants as by-products.

NEW SOURCE PERFORMANCE STANDARDS - WET STORAGE SUBCATEGORY

Based on the information presented in Sections III through VIII, new source performance standards for wet decking raw material storage operations are the same as those identified in Section IX, that is, best practicable control technology. The new source performance standards for pond raw material storage operations is no discharge of process waste water pollutants to navigable waters.

RATIONALE

The storage of raw material in the timber products processing industry usually occurs in out-of-doors situations. The volume of waste water, i.e., water that comes in contact with the raw material is, of course, dependent on the rate and duration of the precipitation event(s) as well as the area of drainage into the wet storage facility. While it is not possible to control the precipitation volume, it is possible to control the area of drainage to a wet storage facility, and to some degree the area of the wet storage facility itself.

The proposed limitation of no discharge of process waste water pollutants for pond storage operations is based on the following considerations. Volumes of process waste water discharged from ponds may be greater because they will usually be located in depressions thus, drainage into the facility will be greater. Materials present in the discharge from a pond may be more concentrated with regard to dissolved materials because of the leaching resulting from soaking. It is also acknowledged that the current trend in the industry is away from pond storage of raw material for among other reasons, the economic benefits that timber products processors can realize from the more efficient utilization of materials achievable in land based storage operations.

NEW SOURCE PERFORMANCE STANDARDS - LOG WASHING SUBCATEGORY

Based on the information presented in Sections III through VIII, the new source performance standards for the log washing subcategory is no discharge of process waste water pollutants to navigable waters.

NEW SOURCE PERFORMANCE STANDARDS - SAWMILLS AND PLANING MILLS SUBCATEGORY

Based on the information presented in Sections III through VIII the new source performance standards for the sawmills and planing mills subcategory is no discharge of process waste water pollutants to navigable waters.

NEW SOURCE PERFORMANCE STANDARDS - FINISHING SUBCATEGORY

Based on the information presented in Sections III through VIII, the new source performance standards for the finishing subcategory is no discharge of process waste water pollutants to navigable waters.

NEW SOURCE PERFORMANCE STANDARDS - PARTICLEBOARD SUBCATEGORY

Based on the information presented in Sections III through VIII, the new source performance standards for the particleboard subcategory is no discharge of process waste water pollutants to navigable waters.

NEW SOURCE PERFORMANCE STANDARDS - INSULATION BOARD MANUFACTURING SUBCATEGORIES

Based on the information presented in Sections III through VIII, new source performance standards for insulation board manufacturing operations are the same as those identified in Section IX:

30-Day Average

Subcategory	BOD5		Total Suspended Solids		pH
	kg/kkg	lb/ton	kg/kkg	lb/ton	--
I	1.25	2.50	3.13	6.25	6-9
II	3.75	7.50	3.13	6.25	6-9

Daily Maximum

Subcategory	BOD5		Total Suspended Solids		pH
	kg/kkg	lb/ton	kg/kkg	lb/ton	--
I	3.75	7.50	9.40	18.8	6-9
II	11.3	22.5	9.40	18.8	6-9

RATIONALE

The best available technology economically achievable discussed in Section X are based in part on the recycling of an estimated 70 percent of the process water after mixed media filtration. This treatment and recycle technology is being evaluated on an experimental basis. However, the degree of reliability has not been proven sufficiently to merit inclusion in the consideration of new source performance standards.

SECTION XII

ACKNOWLEDGEMENTS

This support document is based to a significant degree on a study of the water pollution control aspects of the timber products processing industry conducted by Environmental Science and Engineering, Inc., Gainesville, Florida. Dr. Richard H. Jones served as project director, John D. Crane was project manager. Key staff members were Dr. Larry L. Olson, Leonard P. Levine, John T. White and Jeffrey D. Einhouse.

Reynolds, Smith and Hills, Jacksonville, Florida, Dr. Frank D. Schaumburg, Oregon State University, and Dr. Warren S. Thompson, Mississippi State University provided assistance to the contractor.

Appreciation is extended to the many groups and individuals from the industry who worked with the Agency and the contractor to provide and obtain information useful in the development of the guidelines and standards presented here.

Appreciation is extended to the National Forest Products Association, the National Particleboard Association, the Acoustical and Insulating Materials Association, the Hardwood Plywood Manufacturers Association, the Southern Hardwood Lumber Manufacturers Association and the various industrial advisory committees for their cooperation and assistance. Appreciation is extended to numerous individuals within the industry who supplied information and arranged on-site visits. Individuals who particularly deserve recognition include C. Curtis Peterson, Charles Morchauser, Bruce C. Grefrath, A. F. Trom, Tom Frost, James Leker, William Ames, George Romeiser, Ted Merideth and Robert Lunt.

Intra-agency review, analysis, and assistance was provided by the Timber Products Processing Working Group/Steering Committee. This group included the following EPA personnel:

Harold B. Coughlin, Effluent Guidelines Division, Chairman
Irving Susel, Office of Planning and Evaluation
G. William Frick, Office of Enforcement and General Counsel
Arthur M. Mallon, Office of Research and Development
Al Ewing, Office of Research and Development

Technical guidance and direction was provided by Allen Cywin, Director, Effluent Guidelines Division and Ernst Hall, Deputy Director, Effluent Guidelines Division. D. Robert Quartel served as project officer during the contract phase of this effluent guidelines development program.

Specific thanks are expressed to Nancy Fischer, Darlene Miller and Linda Rose for their assistance in preparing this document for publication.

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SECTION XIV

GLOSSARY

<u>Acrylic Resin</u> - A synthetic, thermoplastic resin formed by polymerizing esters of acrylic acid and methacrylic acid.

<u>"Act"</u> - The Federal Water Pollution Control Act Amendments of 1972.

<u>Activated Sludge Process</u> - A biological waste water treatment process in which a mixture of waste water and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated waste water (mixed liquor) by sedimentation and wasted or returned to the process as needed.

<u>Additive</u> - 1) In board production, any material introduced prior to the final consolidation of a board to improve some property of the final board or to achieve a desired effect in combination with another additive. Additives include binders and other materials. Sometimes a specific additive may perform more than one function. Fillers and preservatives are included under this term. 2) In liquid coatings used in finishing operations, an additive may be any material added to the coating material in its formulation, usually to prevent undesirable effects during its shelf life. Mercuric additives commonly found in paint and coating materials prevent biological contamination during the shelf life of the material.

<u>Aerated Lagoon</u> - A waste water treatment pond in which mechanical or diffused-air aeration is used to supplement the oxygen supply.

<u>Aerobic</u> - A condition in which free, elemental oxygen is present.

<u>Air Classifier</u> - A cylindrical chamber in which small and large wood particles are separated by the introduction of an air stream.

<u>Air Seasoning</u> - See Lumber Drying.

<u>Air Separation</u> - The unit operation associated with the air classification of wood particles by particle size.

<u>Alkyl Resin</u> - A synthetic, thermoplastic resin used in paints, varnishes and lacquers produced by the reaction of a polybasic acid, such as phthalic, maleic or succinic acid, with a polyhydric alcohol such as glycerine.

<u>Anaerobic</u> - A condition in which free elemental oxygen is absent.

<u>Attrition Mill</u> - Machine which produces wood fibers by forcing coarse material, shavings, or pieces of wood between a stationary and a rotating disc fitted with slotted or grooved segments.

Autocatalysis - The catalysis of a reaction by one of its products.

Bagasse - The solid matter remaining after extraction of liquids from sugar cane.

Band Saw - A saw in the form of an endless belt running over wheels.

Barker - Machines which remove bark from logs. Barkers may be wet or dry, depending on whether or not water is used in the operation. There are several types of debarkers including drum barkers, ring barkers, bag barkers, hydraulic barkers, and cutterhead barkers. With the exception of the hydraulic barker, all use abrasion or scraping actions to remove bark. Hydraulic barkers utilize high pressure streams of water.

Bark Mulch - A material used for soil conditioning purposes produced by hogging bark into fine particle size and possibly adding nitrogen in the form of liquid ammonia by spraying.

Barrel Staves - Narrow strips of wood placed edge to edge to form the sides, covering, or lining of a barrel.

Base Coating - See Ground Coating.

Blender - A machine used to blend wood particles and additives in the production of particleboard. Blenders are of two types: 1) A continuous type consists of a horizontal trough with mixing arms and sprayers. Wood particles are fed into the trough while additives are blended in by means of spray nozzles. 2) A batch type consists of a mixing tank with agitation in which the particles and additives are blended.

Blue Stain - A stain imparting a blue color to the wood. This stain is caused by a fungus. The growth of this fungi is retarded by water storage or water spray of the logs.

BOD (biochemical oxygen demand) - is a measure of biological decomposition of organic matter in a water sample. It is determined by measuring the oxygen required by microorganisms to oxidize the organic contaminants of a water sample under standard laboratory conditions. The standard conditions include incubation for five days at 20 C.

BOD7 - A modification of the BOD test in which incubation is maintained for seven days instead of five. This is the standard test in Sweden.

Box Cleat - In the production of wood containers, a small strip of wood fastened perpendicular to the sides to lend lateral support.

Broke System - A system for repulping and reuse of wasted or rejected product to form new product.

Cambium Layer - A thin formative layer between the xylem and phloem of most vascular plants that give rise to new cells and is responsible for secondary growth.

Cant - The remaining portion of a log, either square or rectangular in cross section; after the outside edges or slabs have been sawn or chipped off.

Carriage - See Log Carriage.

Casehardening - A condition of stress and set in wood in which the outer fibers are under compression stress and the inner fibers are under tensile stress, the stress persisting when the wood is uniformly dry throughout.

Casein Resin Glue - A glue commonly used in wood fabricating, made from a derivative of skimmed milk.

Catalyst - An acid or acid salt used to promote quick curing of resins. Common catalysts are ammonium hydroxide, ammonium chloride, and ammonium sulfate.

Caul - A metal plate or screen on which a formed mat of particles or fiber is placed for transfer to the press, and on which the mat rests during the pressing process.

Cellulose - A complex polymeric carbohydrate, $C_6H_{10}O_5$, yielding only glucose on complete hydrolysis, which constitutes the chief part of the cell walls of plants.

Chipping Headrig - Equipment consisting of chipping saws which chip away non-marketable lumber, so that subsequent sawing operations will result in marketable lumber.

Chipper Saw - A saw used to face the side of logs prior to being sawn.

Clarifier - A unit of which the primary purpose is to reduce the amount of suspended matter in a liquid.

Coagulation - The process of becoming viscous or thickened into a coherent mass.

COD (Chemical Oxygen Demand) - A test procedure to give a measure of the oxygen demand equivalent to that portion of matter in a sample which is susceptible to oxidation by a strong chemical oxidant.

Cold Setting - In resin curing, the setting of resins which requires no heat as compared to heat curing.

Containment Pond - See Lagoon.

Cord - A unit of wood equal to a stack 1.22 m by 1.22 m by 2.44 m or 3.625 cu m (four ft by four ft by eight ft or 128 cu ft).

Core Stock - Supply of coarse particles used in the fabrication of the inner core of particleboard.

Correlation Coefficient - A numerical value expressing the degree of association between two variables.

Cross Banding - The transverse reinforcement of panels by wooden strips which are weaker in one direction than in the other, i.e., extruded particleboard.

Curtain Coating - A method used in applying liquid finishing materials usually to flat substrate surfaces. The curtain coating equipment produces a thin, uniform, curtain-like film of liquid material which falls by gravity to the panel substrate as it passes through the coating zone.

Debarker - See Barker.

Debarking - The removal of bark from logs.

Deck - A stack of logs.

Decker - A machine consisting of a wire-covered cylinder, usually with an internal vacuum, over which the suspension of fibers in water is passed in order to clean the pulp and to increase the consistency.

Defibrator - A type of disc-refiner.

Diatomaceous Earth Filter - A type of filter in which diatomaceous earth, a light, friable, siliceous material, is applied to an existing surface prior to filtration.

Dimension Lumber - Lumber sawn to specified dimensions.

Direct Roll Coating - A method used in applying liquid finishing materials to flat substrate surfaces. The equipment consists of an applicator roll which applies the liquid material to the substrate surface, a metering roll which controls the thickness of the liquid material on the applicator roll, and feed and support rolls which feed the panel substrate through the coating device and provide support for the panel against the applicator roll.

Door Skin - The outer wood sheet of a frame-type door.

Double Band Headrig - A pair of band saws used to accomplish initial log breakdown.

Dressed Lumber - Lumber which, not to be marketed as "green" lumber, is further processed by drying and planing. Other treatments such as chemical preservative treatment and end coating are generally applied.

Dry Decking - See Log Storage.

Dust Log - A product produced by injecting sawdust into a mold under heat and pressure without chemical binders.

Dyes - Synthetic or natural organic chemicals that are usually soluble in solvents characterized by good transparency and low specific gravity.

Edge Jointing - See Jointing.

Edger - A stationary circular saw that can be laterally adjusted to rip desired widths of lumber.

Edging - The process of producing specified widths of boards, after a log is reduced into desired thickness.

Embossing - The raising in relief of a surface to produce a design.

End Checking - Cracks which form in logs or lumber because of rapid drying out of the ends.

End Coating - The application of paraffin or other wax emulsion to lumber ends in order to retard end checking.

End Jointing - See Jointing.

Epoxy Resin - By-product of the petroleum industry, commercially produced by a reaction between Bisphenol A, made from phenol and acetone, and Epichlorohydrin, a by-product in the manufacture of synthetic glycerine.

Estuarine Waters - An inland arm of an ocean or the lower end of a river which empties into an ocean; mixtures of fresh and saline waters.

Excelsior - Fine curled wood shavings used especially for packing fragile items.

Extruded Particleboard - A particleboard manufactured by forcing a mass of particles and binder through a heated die with the applied pressure parallel to the faces and in the direction of extruding.

Extruder Applicator - An applicator which applies glue by means of a ribbon to one surface of a board.

Fabricating - The jointing of pieces of wood by mechanical means or adhesives.

Face Stock - Fine particles used in fabrication of the outer layer or the face of particleboard.

Feedworks - Machinery associated with the feeding of logs to the head saw.

Fiber Preparation - The reduction of wood to fiber or pulp, utilizing mechanical, thermal or chemical methods.

Filler - A liquid finishing material, usually containing considerable quantities of pigment, used to build up or fill depressions and imperfections in the surface of the wood substrate.

Finger Joint - A joint produced by machining lumber ends to form interlocking finger-like protrusions.

Finishing - Consists of surface smoothing such as sanding or planing, covering with liquid coatings or covering with various sheet materials or combinations of these operations.

Flaker - A particle formation machine which produces mainly core stock and some face stock for particleboard fabrication. This machine utilizes a series of knives to reduce roundwood and residues to desirable particle sizes.

Flotation Clarifier - A device facilitating solids separation by causing the solids to float to the surface by the aeration of the waste water.

Fluidization of Chips - The process of suspending chips in water for hydraulic transfer.

Fluidized Bed Principle - A principle which produces the equalization of gravity on a particle bed by an influent pressurized gas or liquid. Intraparticle friction causes a pressure drop resulting in the suspension of the particles.

Flush Door - A door manufactured by covering a wooden frame with a skin.

Forming Machine - A device used to form a mat or fiber or particles.

Fourdrinier Machine - A type of forming machine which utilizes the gravity dewatering of stock through a wire screen.

Fractionated Wood - Wood chips, sawdust, planer shavings, etc., derived from roundwood or residual wood. Fractionated wood may be a raw material of some process as in the production of particleboard or a waste product of other operations such as sawmilling.

Furnish - The material used for mill production.

Furniture Stock - Lumber to be used in furniture manufacture.

Gang Saw - A saw which consists of an array of parallel blades mounted in a frame which moves up and down as a log is entered.

Gluing - In fabricating operations, the application of glue to lumber by a double roll spreader or extruder applicator.

Grain Printing - The process of printing a natural wood grain pattern onto the surface of a wood-based product by roll or flat-plate printing using a colored ink or paint to produce an imitation wood grain effect of the surface of the prefinished product.

Green Chain - A handling system for handling green lumber.

Green lumber - Unseasoned wood.

Ground Coating - The cost of colored material, usually opaque, applied before the grain printing ink, in producing imitation wood grain effects for various prefinished wood-based products. Often referred to as base coating.

Groundwood - A fibrous material produced by the stone-grinding of round wood under a shower of water.

Hammermill - A type of particle preparation device which utilizes a mechanical array of steel arms or hammers to flagellate large wood chips into smaller pieces.

Hardboard - A compressed fiberboard of 0.50 to 1.20 g/cu m (31 to 70 lb/cu ft) density. Alternative term: fibrous-felted hardboard.

Hardwood - wood from deciduous or broad leaf trees. Hardwoods include oak, walnut, lavan, elm, cherry, hickory, pecan, maple, birch, gum, cativo, teak, rosewood and mahogany.

Headrig - All machinery utilized to produce the initial breakdown of a log into boards, dimensions or cants.

Headsaw - A single diesel or electric powered saw which breaks down logs into boards.

Heat Curing - The curing of resins by direct heat.

Heat Exchanger - A device which allows the transfer of heat from one media to another.

Hemicellulose - One of a number of substances resembling, but having simpler structures than that of cellulose, and sometimes resulting from the partial hydrolysis of cellulose. The term hemicellulose is also applied to certain constituents of starch, and of the cells of animals.

High-density Overlay - A phenolic resin-impregnated paper most commonly used to overlay softwood plywood panels. Resin content is usually about 45 to 55 percent and the overlay is self-bonding.

Hog Chipper - A device used for reducing the size of particles.

Hog Fuel - Fractionalized wood used to fire a boiler.

Hogged Bark - Bark reduced to a uniform size by passing through an attrition device.

Hot Press - Particleboard mat presses are of three types:

1) Multi-opening hydraulic - consists of 20 to 30 shelves with individual platens which close simultaneously. 2) Single opening hydraulic - mechanically similar to multi-opening; in place of numerous shelves, one long shelf. 3) Continuous - roller type press receives mats in continuous ribbon. Boards are cut to required lengths.

Hydraulic Debarker - See barker.

Hydraulic Press - See Hot Press.

Hydrocarbon - An organic compound containing only carbon and hydrogen and often occurring in petroleum, natural gas, coal and bitumens.

Hydrolysis - A chemical process of decomposition involving splitting of a bond and addition of the elements of water.

Insulation Board - A dried mat of interfelted fibrous material.

Jointing - An operation employed to join two or more pieces of wood in fabricated wood products. Depending on product requirements, joints are of three basic types: edge jointing or side-to-side-grain joints, end to-side-grain joints, and end jointing or end-to-end-grain joints. In all joints the application of adhesives and the subsequent curing process are performed.

Kerf Loss - In a saw mill, the volume of wood lost to sawdust.

Kiln Drying - See Lumber Drying.

Kjld-N - Kjeldahl Nitrogen - Total organic nitrogen plus ammonia of a sample.

Knife Coating - A method used in applying liquid finishing materials, usually of high viscosity, to flat substrate surfaces. The equipment consists basically of a direct roll coater which applies a heavy deposit of liquid material onto the substrate surface. Doctor blades then wipe off the excess material, filling the low spots and pores.

Kraft Paper - A paper of high strength made of sulfate pulp. The paper is commonly impregnated with various resins to be overlaid onto softwood plywood.

Lacquer - A thin-bodied, quick-drying coating material, consisting of a mixture of solutions of nitrocellulose, ethylcellulose and natural and synthetic resins which form a hard film upon drying by evaporation alone.

Lagoon - A pond containing raw or partially treated waste water in which aerobic or anaerobic stabilization occurs.

Laminated Beam - A structural member in which two or more pieces of lumber are joined together face to face usually employing an adhesive.

Laminated Decking - A fabricated wood product which is manufactured by the use of side-to-side-grain joints.

Land Decking - See Log Storage.

Land Spreading - The disposal of process waste water by spreading it on land to achieve degradation by soil bacteria.

Leaching - Mass transfer of chemicals to water from wood materials which are in contact with it.

Lignin - An amorphous polymeric substance related to cellulose that together with cellulose forms the woody cell walls of plants and the bonding material between them.

Linear Regression Analysis - A statistical technique for defining the equation of best fit for two variables.

Log Carriage - A platform on wheels which holds a log in place and, in running parallel to the saw, feeds the log to be cut.

Log Driving - The manned operation of driving or "herding" logs from one point to another on moving waters.

Log Flume - An open channel of water used to feed logs to mills.

Log Gang Mill - See Gang Saw.

Log Pond - See Log Storing.

Log Raft - An aggregation of floating logs, loose or bundles, contained by perimeter logs.

Log Storing - Retaining large inventories of logs to maintain a supply. The four common types of log storing facilities are:

1) Dry-decks - logs stacked on land or land-decked
2) Wet-decks - land-decked logs sprinkled with water to minimize end-checking
3) Log Pond - usually long-term storage of logs by floating them on a body of water
4) Mill Pond - usually short-term storage of logs by floating them on a body of water located at the mill site.

Log Washing - A prebarking process which is carried out by means of sprayers as logs are transported to mill or through storage in log ponds.

Lumber Drying - The process in which lumber is dried by one of two methods:

1) Air seasoning - boards are segregated according to board weight, coated with chemical preservatives and stacked in a manner that will provide sufficient air circulation.
2) Kiln drying - a process whereby green or pre-air seasoned boards are dried in a kiln which is a humidity and temperature controlled building.

Lumber Surfacing (Planing) - A finishing process which is carried out by means of surfacing tools, i.e., planer knives that are attached to a rotating cutterhead.

Machining - One of the several unit operations employed in the timber products industry to produce a desired shape or form for a particular wood product.

Mastic Construction Adhesives - Adhesives consisting of a thick dispersion of various elastomers in an organic solvent, used for example, in adhering panels to frames or plywood to floor joists.

Mat Formation - Part of the manufacturing process of insulation board, particleboard and hardboard, in which fractionated wood or fibers are arranged in a rectangular solid configuration prior to pressing or drying operations.

Mechanical Refining - See Refiner.

Medium-density Overlay - A phenolic resin-impregnated paper, most commonly used to overlay softwood plywood panels. Resin content is usually about 20 to 25 percent and the overlay is not self-bonding.

Melamine Resin - A synthetic, thermosetting resin made from melamine and formaldehyde, which cures quickly at relatively low temperatures, and is characterized by high heat resistance and stability of color.

Melamine-formaldehyde Resin - See Melamine Resin.

Melamine-Urea - A mixture of melamine and urea resins.

Metering Bin - A pre-particle formation apparatus which ensures the homogeneity of wood pieces in order to provide uniformity of feed flow.

Middle Lamella - A protoplasmic layer in wood which separates individual cells.

Mill Feeding - The transportation of logs from log ponds or decks to a mill for processing.

Mill Pond - See Log Storing.

Millwork - Any of a variety of interior woodwork items usually decorative in nature.

Mineral Fiber - Fibers of inorganic nature used in the production of insulation board.

Mixed Media Filtration - A combination of different materials through which waste water or other liquid is passed for the purpose of purification, treatment or conditioning.

Moisture Proofing - The application of moisture resistant compounds to lumber to increase durability and resistance to weathering.

Molded Products - Items produced by the molding of wood particles with resins.

Multiple Saw Headrig - A headrig which has several saws for varied cuts, eliminating multiple passes by the headsaw, thus increasing efficiency.

Narrow-Kerf Saw - A saw with a thinner blade than normally used.

Oligosaccharide - A sugar which contains units of from two up to eight simple sugars.

Overrun - In a saw mill, the difference between the measured volume of a log and the actual volume of the lumber produced.

Particleboard - A sheet material manufactured from lignocellulosic pieces or particles, as distinguished from fibers, combined with a synthetic resin or other suitable binder and bonded together under heat and pressure in a hot-press, or extruded, by a process in which the entire inter-particle bond is created by the added binder.

Patching Material - A high viscosity, putty-like substance commonly used to fill knot holes and other large surface defects in the face veneers of plywood panels as one of the initial steps in the manufacture of prefinished panels.

Pentachlorophenol - A crystalline compound, C_6Cl_5OH, used as a wood preservative, fungicide and disinfectant.

pH - A measure of acidity or alkalinity of a water sample. It is equal to the negative log of the hydrogen ion concentration.

Phenols - A class of aromatic organic compounds in which one or more hydroxy groups are attached directly to the benzene ring.

Phenol-formaldehyde Resin - A synthetic, oil soluble resin produced as a condensation product of phenol and formaldehyde.

Phenolic Resins - Synthetic, thermosetting resins, usually made by the reaction of phenol with an aldehyde.

Picker Roll - Device used to ensure uniform mat thickness in the dry felting operation.

Pigment - The fine, solid particles used for color or other properties in the manufacture of paints and coatings.

Pitch - An organic deposit composed of condensed hydrocarbons removed from the wood and which may deposit on the surface of saw blades.

Planer Shavings - See Fractionated Wood.

Planing Mill - Consists of planers which produce smooth surfaces on lumber.

Platens - The flat plates in the hot-press which compress the mats into particleboards.

Polyester Resin - A synthetic, thermosetting resin formed by a chain of molecules, composed alternately of molecules of acid and alcohol. The chain formation linking the molecules together is polymerization.

Polymerization - A chemical reaction involving a successive linkage of molecules.

Polyvinyl Acetate Resins - Synthetic, thermoplastic resins, commonly used in the manufacture of emulsion coatings.

Polyvinyl Chloride Film - A special plastic film produced by calendering techniques and used in overlaying various wood-based substrates to produce textured and printed decorative products.

Prefinished Panels - Any type of wood-based panel which is factory finished and requires no further finishing by the user.

Pregluing - Operations concerned with drying, preservative dipping or spraying, planing, grading, end or edge jointing and cutting to length. These are necessary steps to prepare lumber for gluing.

Prepress - A press which prepares particle mats for the hot press by partial consolidation of fibers.

Preservative Dipping - The chemical treatment of green lumber prior to stacking. Lumber is dipped in a bath solution usually containing pentachlorophenol.

Pressed Bark - Bark transformed into logs or briquettes under pressure and heat.

Press Pit - A sump under the press.

Press Platen - See Platen.

Primary Clarifier - The first settling tank through which waste water is passed in a treatment system.

Prime Coating or Primer - A special coating designed to provide adequate adhesion of a coating system to an uncoated wood surface and thus to allow for the exceptional absorption of the medium.

Product Mix - The fractional breakdown of the sum total of different types of products produced in a plant.

Protein Resin - A protein based resin; usually soya based.

Pulping System - A fiber preparation system.

Quad Band Headrig - Two pairs of band saws used to accomplish initial log breakdown.

Radio Frequency Curing - A method of curing synthetic resin glues by radio frequency heat generated by the application of an alternating electric current, oscillating in the radio frequency range, to a dielectric material.

Refiners - Particle forming machines. Refiners are of two types:

1) Mechanical Refiner - a particle forming machine consisting of either two rotating disks or a rotating disk and a stationary plate. The particles produced in passing through the rotating apparatus are fine in nature and thus are used for face stock.
2) Thermo-mechanical Refiner - A disk type particle forming machine which employs the aid of heat and pressure to soften the feed wood, producing fibers that are longer and stronger than those of a standard mechanical refiner.

Rehumidification - The addition of moisture to a finished board to prevent warping.

Resin - A semi-solid or solid mixture of organic or carbon-based compounds which may be drawn from animal, vegetable or synthetic sources and may be thermosetting or thermoplastic.

Resin-Impregnated Paper - A type of paper, most commonly either heavy kraft paper or refined alpha paper impregnated to varying degrees of saturation with various types of resins for the purpose of overlaying plywood and other types of wood-based panels. The most common types of resins used are: melamine and phenolic formaldehyde, polyester resins and acrylic types.

Resonance Frequency Device - A heating device using high frequency radio waves to internally cure resins in particleboard.

Resorcinol - A crystalline phenol with the formula $C_6H_4(OH)_2$ obtained from various resins or artifically and used in making resins.

Reverse Roll Coating - A method used in applying liquid finishing materials to flat substrate surfaces. The equipment consists basically of two parts; first, a direct roll coater which deposits a heavy coat of liquid material onto the substrate surface; second, a highly polished, chrome plated roll, rotating in the opposite direction of the applicator roll. The reverse acting roll wipes and polishes the substrate surface, filling the low spots and pores and removing the excess liquid material.

Ring Debarker - See Barker.

River Impoundment - A natural or man-made area of a river which is suited for the grouping and storage of logs.

Rotary Jet Drum Dryer - A particle dryer which uses a high-velocity air jet to produce a spiral flow of particles in a horizontal drum.

Roundwood - Wood that is still in the form of a log.

Rubber-Base Contact Cement - Typically a dispersion of neoprene elastomer in organic solvents. Used quite extensively in the bonding of decorative plastic laminates to plywood or particleboard normally applied to both surfaces and allowed to dry to a tack-free state before assembly.

Sawdust - See Fractionated Wood.

Saw Mill - A plant which consists of varied operations necessary to reduce the raw material, i.e., log or cant to a useable wood product.

Scrag Mill - Generally used for small diameter logs, consisting of one or more pairs of circular saws with each pair in tandem.

Sealer - A liquid finishing material which is applied with the primary purpose of stopping the absorption of succeeding coats.

Seal Water - Water used as a seal in vacuum pumps.

Sedimentation - The gravity separation of suspended solids.

Septic Tank - A single-story settling tank in which the settled sludge is in immediate contact with the waste water flowing through the tank, while the organic solids are decomposed by anaerobic bacterial action.

Settling Ponds - An impoundment for the settling out of settleable solids.

Settling Tank - A tank or basin, in which water, domestic sewage, or other liquid containing, settleable solids, is retained for a sufficient time, and in which the velocity of flow is sufficiently low to remove by gravity a part of the suspended matter.

Setworks - The devices used to secure and position the logs on a carriage for cutting.

Shake - A shingle split from a piece of log, usually three or four ft long.

Sheathing - Asphalt impregnated insulation board.

Shotgun - A piston-cylinder arrangement, steam, air, or hydraulic driven, which powers the log carriage.

Size - An additive which increases water resistance.

Slash - To cut logs to size.

Softwood - Wood from evergreen or needle bearing trees.

Solvent Base Coatings - All non-water base or non-water soluble coating materials.

Solvents - Products which dissolve or disperse the film forming constituents of surface coating materials which usually volatilize during drying and therefore do not become a part of the film itself. Solvents are required to control the consistency of the liquid finishing material to obtain suitable applicating properties.

Sound Deadening Board - A type of insulation board that has to meet only minimal industrial standards.

Special Plastic Films - A wide variety of thermoplastic films widely used for overlaying various types of wood-based substances.

Specialty Mill - A saw mill which produces a particular specialty item rather than a general range of products.

Spray Booth - An enclosure, used in conjunction with spray coating equipment, designed to provide fire and air pollution protection by removal of both the solvent fumes and the spray mist associated with spray coating operations. Spray booths are of two types: 1) a water-wash type which uses water as the filtering media and 2) a dry-type which uses dry filter elements.

Spray Coating - A method used in applying liquid finishing materials to almost all types of wood-based substrates, accomplished by various types of spray equipment including fixed gun, reciprocating arm and rotary arm spray equipment.

Spray Evaporation - A method of waste water disposal in which the water in a holding lagoon equipped with spray nozzles is sprayed into the air to expedite evaporation.

Spray Irrigation - A method of disposing of some organic waste waters by spraying them on land, usually from pipes equipped with spray nozzles.

Stabilizers - Materials such as compounds of lead, tin and cadmium-barium commonly added to resin compounds to minimize chemical degradation when the material is exposed to elevated temperatures or ultraviolet rays of the sun.

Stain - A transparent or semi-transparent liquid material made from dyes, finely divided pigments or chemicals which when applied to wood surfaces changes the color without disturbing the texture or markings.

Staining - A spraying process which gives lumber a more pleasing color.

Steaming - Treating wood material with steam to soften it.

Substrate - A material such as a wood-based panel coating or adhesive containing substance is applied for the purpose of finishing or bonding of an overlay.

Surge Area or Bin - An area in the forming machine which consists of a bin that is kept at a constant level so that continuity of particle flow is maintained.

Synthetic Resins - Complex, organic semisolid or solid materials built up by chemical reaction of comparatively simple compounds. Synthetic resins often approximate the natural resins in various physical properties; namely, luster, fracture, comparative brittleness, insolubility in water, fusibility, or plasticity when exposed to heat and pressure and, at a certain more or less narrow temperature range before fusion, a degree of rubber like extensibility. They commonly deviate widely from natural resins in chemical constitution and behavior with reagents.

Tack - The ability of a resin to adhere.

Thermomechanical Pulping - Fiber preparation by disk refining and pretreatment of the wood by pressurized steam.

Thermomechanical Refining - See Refining.

Thermoplastic Resins - Resins which soften and may be reformed under heat and pressure.

Thermosetting Resins - Resins which undergo permanent physical and chemical change through the application of heat and pressure.

Ties - Conventional rail and track ties.

TLM 96 - The concentration of a toxic substance that causes half of a group of test organisms to die by the end of 96 hours.

Top Coat - A liquid finishing material, usually applied as the final finish coating for any prefinished wood product.

Total Tree Harvesting - The in situ chipping and subsequent utilization of a whole tree.

T-PO4-P - Total phosphate as phosphorus.

Trimming - The final sawing of boards, prior to drying, to square ends of lumber and remove defects.

TSS (Total Suspended Solids) - Total material retained by a filler of a specified porosity, expressed in mg/l.

Tunnel Dryer - An enclosure through which wet mats are passed and dried by means of forced hot air.

Turbidity - 1) A condition in water or waste water caused by the presence of suspended matter, resulting in the scattering and absorption of light rays. 2) A measure of the fine suspended matter in liquids. 3) An analytical quantity usually reported in arbitrary turbidity units determined by measurements of light defraction.

Urea-formaldehyde Resin - A synthetic resin produced by condensing urea with formaldehyde.

Urea-Resin Glue - A synthetic-resin adhesive system based on the thermosetting, urea-formaldehyde resin, used in overlaying veneers and hardboard onto particleboard substrates as well as in other wood gluing operations.

V or U-Grooves - Machine cut grooves, cut into wood-based panel substrates in the production of prefinished wall paneling.

Grooves are usually either V or U-shaped and are regularly or random-spaced throughout the length of the panel.

Varnish - A homogeneous transparent or translucent liquid material which, when applied as a thin film, hardens upon exposure to air or heat, by evaporation, oxidation, polymerization or a combination of these to form a continuous film that imparts protective or decorative properties to wood finishes.

Veneer Cutting - There are four basic methods:

1) Rotary lathing - cutting continuous strips by the use of a stationary knife and a lathe.
2) Slicing - consists of a stationary knife and an upward and downward moving log bed. On each down stroke a slice of veneer is cut.
3) Stay log - A flitch is attached to a "stay log," or a long flanged, steel casting mounted in eccentric chucks on a conventional lathe.
4) Sawn veneer - veneer cut by a circular type saw called a segment saw. This method produces only a very small quantity of veneer. (see also Segment Saw)

Veneer Drying - Freshly cut veneers are ordinarily unsuited for gluing because of their wetness and are also susceptible to molds, fungi, and blue stain. Veneer is usually dried as soon as possible, to a moisture content of about 10 percent.

Vinyl Acetate - A colorless liquid with the formula $CH_2CHCO_2CH_3$ used in the manufacture of synthetic vinyl resins.

Vinyl Resins - Synthetic, thermoplastic resins formed by the polymerization of a vinyl compound, with or without some other substance.

Water Base or Water Reducible Coatings - Emulsions (of high molecular weight), dispersions (of fine particle size) and other water soluble coating systems which, at application of solids, comprise a minimum of 80 per cent of their volatile as water, with the balance as exempt solvent.

Water Soluble Adhesive - An adhesive requiring water for preparation; used in product fabrication and finishing operations.

Wax Emulsion - A sizing compound.

Wet Decking - See Log Storing.

Wet Scrubber - An air pollution control device which involves the wetting of particles in an air stream and the impingement of wet or dry particles on collecting surfaces followed by flushing.

Wood Chips - See Fractionated Wood.

Wood Flour - Produced from the attrition of wood materials into very small particles.

TABLE 104

CONVERSION TABLE

MULTIPLY	ABBREVIATION	by CONVERSION	ABBREVIATION	TO OBTAIN
acre	ac	0.405	ha	hectares
acre - feet	ac ft	1233.5	cu m	cubic meters
board foot	bd ft	12.0	cu ft	cubic feet
British Thermal Unit	BTU	0.252	kg cal	kilogram-calories
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg	kilogram calories/ kilogram
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	°F	0.555 (°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	kilowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
pounds/cubic ft	lb/cu ft	16.05	kg/cu m	kilograms/cubic meters
million gallons/day	mgd	3,785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (guage)	psig	(0.06805 psig +1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square centimeters
square inches	sq in	6.452	sq cm	square centimeters
1000 board ft	1000 bd ft	2.36	cu m	cubic meters
tons (short)	ton	0.907	kkg	metric tons (1000 kilograms)
yard	yd	0.9144	m	meters

*Actual conversion, not a multiplier