URBAN RECYCLED WOOD
CHARACTERIZATION STUDY

Final Report

Prepared for

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TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**

1.0 INTRODUCTION **4**

1.1 BACKGROUND *4*

2.0 METHODOLOGY **5**

2.1 END USER SURVEY *5*
2.2 URBAN RECYCLED WOOD CHARACTERIZATION *5*

3.0 END USER SURVEY RESULTS **10**

3.1 BACKGROUND *10*
3.2 BIOMASS FUEL END USE *12*
3.2.1 Summary *12*
3.2.2 Issues Regarding Size and Shape *12*
3.2.3 Contaminant Issues *14*
3.3 COMPOSITE WOOD MANUFACTURING *15*
3.3.1 Summary *15*
3.3.2 Issues Regarding Size and Shape *16*
3.3.3 Contaminant Issues *17*
3. 4 PULP AND PAPER MANUFACTURING *19*
3.4.1 Summary *19*
3.4.2 Issues Regarding Size and Shape *20*
3.4.3 Contaminant Issues *21*

4.0 URBAN RECYCLED WOOD CHARACTERIZATION RESULTS **23**

4.1 URBAN RECYCLED WOOD PROCESSING FACILITY DESCRIPTIONS *23*
4.1.1 Facility 1 .... *23*
4.1.2 Facility 2 .... *26*
4.1.3 Facility 3 .... *28*
4.1.4 Facility 4 .... *30*
4.2 CHARACTERIZATION RESULTS *33*
4.2.1 Facility 1 .... *33*
4.2.2 Facility 2 .... *35*
4.2.3 Facility 3 .... *38*
4.2.4 Facility 4 .... *41*

5.0 END USER TECHNICAL DISCUSSIONS **43**

5.1 INTRODUCTION *43*
5.2 URBAN RECYCLED WOOD CONTAMINANT CONTENT AND QUALITY *44*
5.3 HANDLING AND PROCESSING ISSUES *48*
5.4 ECONOMICS *48*

6.0 CONCLUSIONS AND RECOMMENDATIONS **49**

Appendices:

Appendix A: End User Survey
Appendix B. End User Technical Discussions

List of Tables

Table l Brightness Rating Scale
Table 2 URW End Use Survey Results: Size and Shape Specifications
Table 3 URW End Use Survey Results: Contaminant Content (%) Specifications
Table 4 URW End Use Survey Results: Moisture & Brightness Requirements
Table 5 Size and Shape Specifications - Biomass Energy End Use
Table 6 Contaminant Content (%) Specifications - Biomass Energy End Use
Table 7 Size and Shape Specifications - Composite Wood Manufacturing End Use
Table 8 Contaminant Content (%) Specifications - Composite Wood Manufacturing
Table 9 Moisture, Brightness, and Species Requirements - Composite Wood Manufacturing
Table 10 Size and Shape Specifications - Pulp and Paper Manufacturing End Use
Table 11 Contaminant Content (%) Specifications - Pulp and Paper Manufacturing
Table 12 Moisture, Brightness, and Species Requirements - Pulp and Paper Manufacturing
Table 13 Facility 1 Overview
Table 14 Facility 2 Overview
Table 15 Facility 3 Overview
Table 16 Facility 4 Overview
Table 17 Facility 2 URW Characterization Results (Biomass Energy End Use)
Table 18 Facility 2 URW Characterization Results (Biomass Energy End Use)
Table 19 Facility 2 URW Characterization Results (Manufacturing End Use)
Table 20 Facility 3 URW Characterization Results (Biomass Energy End Use)
Table 21 Facility 3 URW Characterization Results (Manufacturing End Use)
Table 22 Facility 4 URW Characterization Results (Manufacturing End Use)
Table 23 Effect of Specific Contaminants on the Manufacturing Process
Table 24 Effect of Specific Contaminants on Product Function
Table 25 Effect of Specific Contaminants on Product Aesthetics

List of Figures

Figure 1 Sample Collection and Analysis Flow Chart
Figure 2 Facility 1 Processing Schematic
Figure 3 Facility 2 Processing Schematic
Figure 4 Facility 3 Processing Schematic
Figure 5 Facility 4 Processing Schematic

Executive Summary

Over the last several years, the amount of urban wood waste recycled in Washington State has increased from 100,000 tons per year to over 640,000 tons per year. Considerable success has been achieved in developing end uses and markets for this material. The pulp and paper and composite wood manufacturing industries have used this material as a manufacturing feedstock. However, market development has been curtailed by a poor understanding of product quality, end-user requirements, perception about demolition wood, and regulatory constraints.

In recognition of these constraints, the Clean Washington Center sponsored a project to:

1. Determine end-use specifications for use of urban recycled wood (URW) as a biomass fuel and feedstock for pulp and paper and composite wood manufacturing.
2. Characterize URW produced by four processors in Washington State.
3. Convene end users discussion groups with end user industry representatives.

A survey was conducted to determine end-user specifications in the composite wood, pulp and paper and biomass energy industries. Results indicated that many of the respondents who had used URW as a manufacturing feedstock experienced problems with excessive contamination. Few of these companies use URW as a manufacturing feedstock because of the low cost of virgin fiber but indicated that URW would be an important source of fiber in the future.

The URW characterization component of the project involved collecting and characterizing URW samples from four URW processing facilities. A sampling procedure was developed to ensure the collection of a representative sample. The collected URW samples were analyzed for inert contaminants (i.e. plastic, metal, painted wood, etc.), sieve analysis, moisture, ash, heat energy and trace metal content. The results were analyzed to determine feedstock variability, potential methods for improving the quality of the product, and how well the various URW products met end use specifications.

In addition, end-users and composite wood and pulp and paper manufacturing industry representatives met to discuss the constraints of using URW as a manufacturing feedstock. A main concern was the quality of processed URW and the significant affect of various contaminants on the manufacturing process and the quality of the manufactured product. Contaminants such as plastic, sand and grit, metals and other inert materials have a significant effect on the manufacturing process and product quality. The consensus was that contaminated URW was a constraint to its use.

The contamination issue was prevalent several years ago when URW was first used in composite wood and pulp and paper manufacturing processes and when both the URW processors and the end-users were first learning how to process and use URW. Since that start-up period, the remaining URW processors have developed more sophisticated techniques for sourcing clean materials and removing contaminants. Manufacturers using URW have also learned how to better utilize URW as a manufacturing feedstock.

Project results indicated that many firms had some experience using URW as a biomass fuel or manufacturing feedstock. The specifications and technical requirements for using URW as a biomass fuel are less stringent than for manufacturing end-uses. Consequently, this market has been the easiest to access. Currently, most URW is placed in this market and the end-users seem satisfied with the quality and performance of the product.

Based on the findings of this project, the market for biomass fuel is expanding and should provide a stable market for URW in the future. However, in order for this market to remain substantial, URW processors need to work closely with the end-user to provide a product that meets their end-use requirements.

In contrast to the URW specifications for the end-use option of biomass fuel, specifications and technical requirements for using URW as a manufacturing feedstock are more stringent. As a result, it has been more difficult for URW processors to place materials in this end-use market. Part of this problem is due to the learning curve the processors and manufacturers experienced several years ago. Unaware of the challenges in using URW, many manufacturers experienced difficulties and quickly discontinued using URW when virgin feedstocks became more readily available at low prices.

Since URW was first used as a manufacturing feedstock, processors still in the business have made modifications to their manufacturing process and have learned how to better use this material. Consequently, they are producing a very clean, consistent product.

1.0 INTRODUCTION

1.1 BACKGROUND

Over the last several years, the amount of urban wood waste recycled in Washington State has increased from approximately 100,000 tons per year to 640,000 tons per year. A large fraction of the urban (and suburban) wood being recycled is “clean” wood waste and consists primarily of mill residuals, land clearing debris, and pallets and crates. A smaller quantity of construction and demolition (C&D) wood waste is recycled. A primary barrier to recycling C&D wood waste is market development, which has been inhibited by a poor understanding of product quality, end user requirements, negative perceptions about "contaminated" demolition wood, and regulatory constraints.

In recognition of these constraints for developing markets for urban recycled wood (URW), the Clean Washington Center’s Recycling Technology Assistance Partnership sponsored a project to determine end use specifications, characterize URW and establish the opportunity for placing URW in various manufacturing processes. The results of this project will increase the competitiveness of wood waste products by:

- Helping processors understand the characteristics of their product relative to the specifications and constraints of the marketplace;
- Providing processors with technical and market information needed to initiate processing or increase processing capacity;
- Providing end users with feedstock quality data; and
- Providing regulatory officials with technical information that will encourage the development of reasonable regulations.

A survey was conducted to determine end-user specifications in the composite wood, pulp and paper and biomass energy industries. Two of the primary barriers indicated by survey respondents include: 1) many of the respondents who had used URW as a manufacturing feedstock experienced problems with excessive contamination; and (2) few of the companies use URW as a manufacturing feedstock because of the low cost of virgin fiber but indicated that URW would be an important source of fiber in the future.

The URW characterization component of the project involved collecting and characterizing URW samples from four URW processing facilities. A sampling procedure was developed to ensure the collection of a representative sample. The collected URW samples were analyzed for contaminants, sieve analysis, moisture, ash, heat energy and trace metal content. The results were analyzed to determine feedstock variability, potential methods for improving the quality of the product, and how well the various URW products met end-use specifications.

2.0 METHODOLOGY

2.1 END USER SURVEY

The primary focus of this report was to define the end users specifications and known constraints to using urban wood debris. A survey tool was developed (Appendix A) for eliciting information from end users about their experience with URW. A database was developed of potential major end users of URW. The survey was mailed to 35 potential and current users of URW. Of those surveyed, 9 manufacture pulp and paper, 12 manufacture composite wood products, and the remaining 14 generate energy from biomass. Within two weeks of mailing the survey, all of the firms were contacted by telephone (even if they returned the survey). The firms contacted in the survey are not identified in this report.

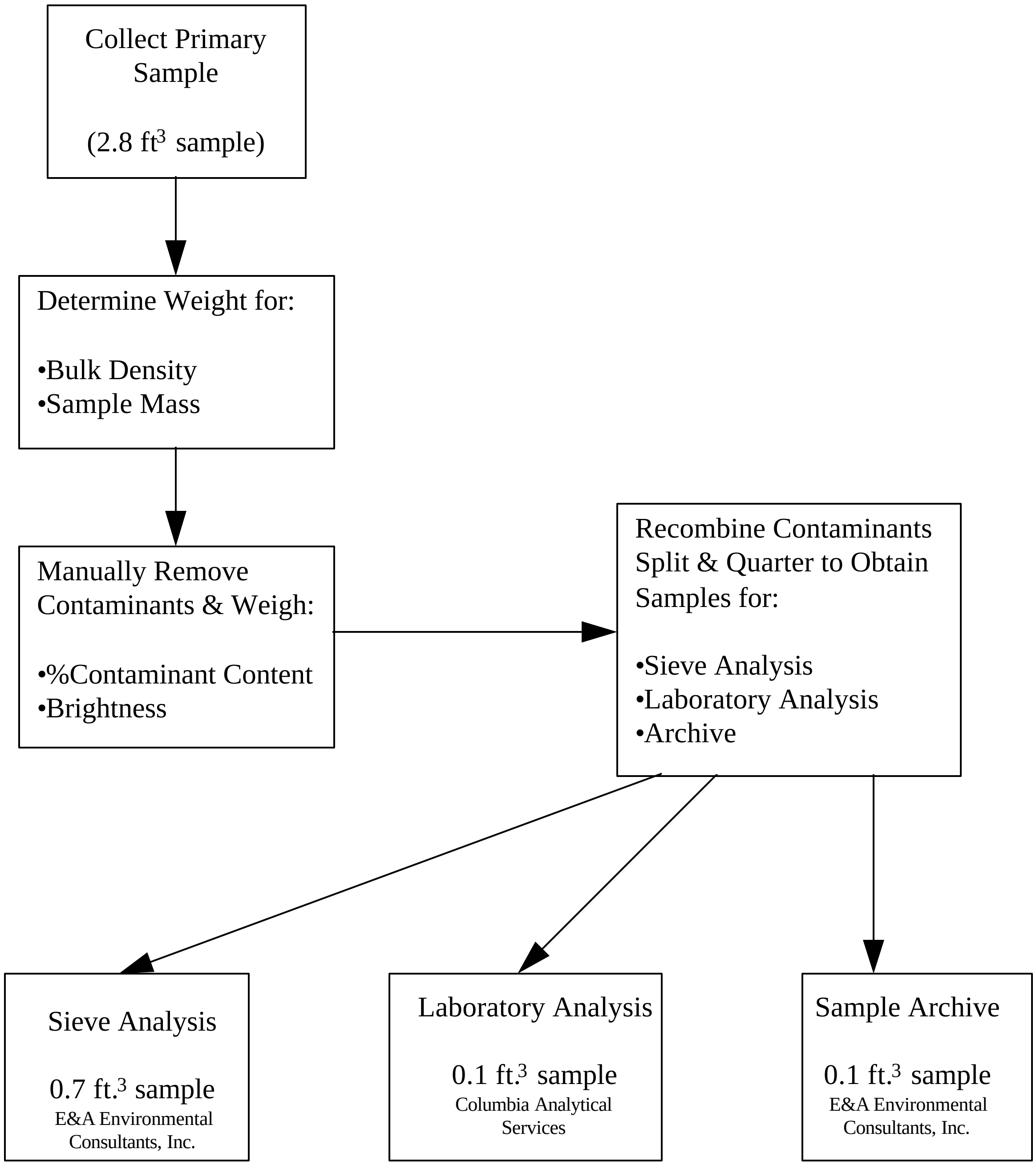
2.2 URBAN RECYCLED WOOD CHARACTERIZATION

Samples were collected for analysis from four processing facilities. An overview of the sample collection and analysis procedure is presented in Figure 1. Between September 16, 1996, and

February 2, 1997, four URW samples were collected from the following URW processing facilities located in Washington State:

- Waste Management, Inc., Seattle
- H&H Wood Recyclers, Inc., Vancouver
- Horizon Wood Recyclers, Sultan
- Northwest Fiber and Wood Recovery, Auburn

Figure 1: Sample Collection and Analysis Flow Chart



At each facility, an initial representative, composite sample was collected and prepared. The sample was at least 2.8 cubic feet and from a stockpile containing at least 50 cubic yards of processed URW. In order to obtain a representative sample, it was collected from at least four different locations and at a minimum depth of six inches. The green weight and volume of the initial sample was determined.

The inert contaminant content was determined by examining the entire sample in one gallon subsamples and then manually removing any inert contaminants. Inert contaminants included all non-wood items (rocks, plastic, metals, roofing material, and styrofoam), composite wood products (oriented strand board, plywood, and particleboard), painted wood, and treated wood. The weight of each contaminant category was determined with a triple beam balance to the nearest gram and the percentage of contaminant content was calculated.

After determining the contaminant content, subsamples were obtained for laboratory analysis. The contaminants were mixed back into the initial sample and the entire sample was mixed. Using a "cone and quarter" sampling procedure, representative subsamples of the sample were collected for analysis. The cone and quarter procedure entailed the homogenization of the primary sample followed by the formation of a cone that was split into quarters. One of the quarters was discarded and the remaining three quarters were mixed. This procedure was repeated until the desired sample volume remained. The subsamples included a 0.7 cubic foot (cf) gallon sample for sieve analysis, a 0.1 cf gallon sample for laboratory analysis, and a 0.1 cf gallon sample for archiving. The brightness of each sample was determined by E&A Environmental Consultants, Inc. (E&A) according to the brightness index presented in Table 1.

Table 1: Brightness Rating Scale

Brightness Rating	Brightness Description
1	Very bright, no dirty or dark wood present
2	Moderately bright, less than 10% of the surface area is dirty or dark wood
3	Dark, more than 10% of the surface area is dirty or dark wood
4	Very dark, more than 50% of the surface area is dirty or dark wood

The sieve analysis conducted by E&A was performed by hand, using six, eight-inch diameter ASTM standard sieves with square hole openings measuring 1-inch, 5/8-inch, 3/8-inch, 5/16-inch, 3/16-inch, and 1/25-inch. The top sieve was loaded to approximately three-quarters capacity and the entire stack of sieves was manually shaken back and forth 50 times on a horizontal plane. Limiting the sieve shaking time reduced the amount of long thin particles "spearing" through the sieves. Fraction larger than one-inch was manually measured and all pieces larger than three inches were segregated and identified as the greater than three-inch fraction.

A single subsample from each sampling event was forwarded for analysis to Columbia Analytical Services in Kelso, Washington. Prior to analysis, the laboratory mechanically ground a representative subsample (of the received sample) to pass a quarter-inch sieve. This procedure is necessary because many analytical testing procedures use less than a gram of sample. A representative one-gram sample was obtained for analysis by grinding and homogenizing the large-sized wood debris samples. The wood debris samples were analyzed for the following parameters:

- Total solids
- Volatile solids
- BTU content* (hog fuel only)
- Trace metal* content (arsenic, cadmium, chromium, copper, lead, nickel, and zinc).

* The BTU content and trace metal content are only important for characterizing URW to be used as hog fuel only.

During the site visits to each facility, the following information was obtained on how the facility was being operated:

- Sources of urban wood debris
- Pre-sorting activities at generation and processing sites
- Age of stockpile
- Intended market
- Description of process train and primary processing equipment

3.0 END USER SURVEY RESULTS

3.1 BACKGROUND

The purpose of the urban recycled wood (URW) end user survey was to collect information regarding the use of URW materials by specific end users. One of the survey objectives was to obtain specifications for procuring URW as energy and manufacturing feedstocks. Results of the survey are discussed according to the end uses. Of those surveyed, 9 manufacture pulp and paper, 12 manufacture composite wood products, and the remaining 14 generate energy from biomass. Tables 2, 3 and 4 summarize the survey results. Note: In this report of survey results, the term URW refers to all types of urban wood debris, including mill residuals and construction and demolition and land clearing debris (CDL).

Table 2: Urban Recycled Wood End Use Survey Results: Size and Shape Specifications

End-Use	Dimensions (inches)					
	Length		Width		Thickness	
	Range	Avg	Range	Avg	Range	Avg
Biomass Fuel	1.0 – 24.0	4.4	1.0 - 6.0	2.9	1.0 - 4.0	2.6
Composite Wood	0.38 - 3.0	1.63	0.38 - 3.0	1.35	0.13 - 3.00	0.66
Pulp & Paper	0.88 - 3.0	1.50	0.88 - 3.0	1.50	0.13 - 0.39	0.26

End-Use	Overs		Fines Content			
	Maximum % Allowed		Maximum % Allowed		Size (inches)	
	Range	Avg	Range	Avg	Range	Avg
Biomass Fuel	0 – 10.0	7	5.0 – 33.0	14	0.13 - 0.25	0.18
Composite Wood	0 – 20.0	8.2	2.0 – 40.0	10.3	0.02 - 0.25	0.15
Pulp & Paper	0.5 10.0	5.2	1.5 – 5.0	3.3	0.12 - 0.19	0.15

Table 3: URW End Use Survey Results: Contaminant Content (%) Specifications

End-Use	Contaminants (Range of Percent by Weight)							
	Bark	OSB	MDF	Painted Wood	Treated Wood	Soil & Rocks	Metals	Plastics
	Range	Range	Range	Range	Range	Range	Range	Range
Biomass	nl	0 – nl	0 – nl	0 – nl	0 - nl	0 – 1	0 – 1	0 – 1
Composite Wood	0 - 18	0 – 25	0 – 5	0 – 0	0 – 0	0 - 1	0 - 1	0 - 0.001
Pulp & Paper	0.2 – 5.0	0 - 0	0 - 0	0 – 0	0 – 0	0 - 1	0 - 1	0 - 0

nl – No Limit

Table 4: URW End Use Survey Results: Moisture and Brightness Requirements

End-Use	Moisture Content (%) (nl = No Limit)		Brightness Specifications
	Range	Average	
Composite Wood	Min. 0 – 50 Max. 12 – 90	17 47	25% of respondents do require minimum brightness level
Pulp & Paper	Min. nl Max. nl	--- ---	67% do require minimum brightness level

3.2 BIOMASS FUEL END USE

3.2.1 Summary

Fourteen firms who use biomass fuel supplied information. Eighty-six percent of the respondents have used URW as a fuel and 79% are currently using URW as a fuel. The majority of end users experienced minor problems using URW as a fuel; these problems are discussed in respective section topics below.

3.2.2 Issues Regarding Size and Shape

Most end users accept a fairly coarse material as a fuel feedstock (Table 2). About 70% of the respondents can use a URW feedstock that is three inches in length or greater. One respondent uses a hog mill to process incoming URW and can accept larger-sized material as long as two feet. All of the respondents indicated that a shred material is acceptable, as long as it meets the size specifications.

The primary issue regarding the size of URW as a hog fuel is the conveyance of feedstocks from the fuel storage area into the boiler combustion chamber. System shutdown can occur when a large portion of oversized materials clog the conveyors and other equipment used to move the

URW. Most of the facilities can handle URW having overs content of 5-10%. Several firms indicated that handling problems could result if the overs content exceeds a specified level.

The fines content of a fuel feedstock is of less concern than the oversized fraction. About 60% of the respondents indicated that fines are of no concern or only require periodic attention when fine content gets too high. Dust control is a primary issue regarding fines because of the health impacts on workers. Combustibility of the feedstock is also an issue, as several respondents indicated that fine material does not burn as well in their boiler as does coarser material.

Table 5: Size and Shape Specifications - Biomass Energy End Use

Company	Dimensions (inches)			Overs	Fines Content		Shred Wood Acceptable ?
	Length	Width	Thick	Max (%)	Max (%)	Size (in.)	
End User 1	2.5	2.5	2.5	10	nl	---	Yes
End User 2	24.0	6.0	2.0	0	15	3/16	Yes
End User 3	4.0	4.0	4.0	10	nl	---	Yes
End User 4	4.0	1.0	1.0	10	nl	---	Yes
End User 5	4.0	4.0	4.0	5	10	1/4	Yes
End User 6	3.0	3.0	3.0	ns	a	a	Yes
End User 7	3.0	3.0	3.0	10	nl	---	Yes
End User 8	1.0	1.0	1.0	ns	ns	---	Yes
End User 9	3.0	3.0	3.0	0	nl	---	Yes
End User 10	1.5	1.5	1.5	10	nl	---	Yes
End User 11	2.0	2.0	2.0	5	5	3/16	Yes
End User 12	3.0	3.0	3.0	10	33	1/8	Yes
End User 13	3.0	3.0	3.0	10	nl	---	Yes
End User 14	3.0	3.0	3.0	5	5	1/8	Yes
Average	4.4	2.9	2.6	7	14	0.18	
Std. Deviation	5.7	1.3	1.0	4	12	0.05	
Maximum	24.0	6.0	4.0	10	33	0.25	
Minimum	1.0	1.0	1.0	0	5	0.13	

ns - Not specified
nl - No limit
a - Fines can cause dust problems, evaluated on a case by case basis

3.2.3 Contaminant Issues

Contaminants affect two major facets in the attempt to use URW as a fuel; regulations and boiler operation. Data obtained for this report came from facilities that are permitted to burn wood only. Burning other materials such as paper and plastic would require the facility to be permitted as an incinerator and would require a significant upgrade in emissions control equipment and a lengthy, expensive permitting process. According to Jim Knudsen of the Washington Department of Ecology, each facility (regardless of size) is allowed to burn up to 12 tons of URW per day from a source contaminated with waste materials (i.e. demolition debris that contains plastic). Contaminants such as dirt, sand, rocks, and metal can affect the performance of the boiler. In addition to having no BTU value, these contaminants increase the amount of ash disposal and also can clog grates to cause a shutdown.

Respondents indicated that their facilities have no tolerance for dirt, metals, plastic, and painted URW, as shown in Table 3. However, they were aware that a certain amount of these contaminants are received. There is no regular testing of incoming fuel feedstocks and it would be difficult to obtain and analyze representative samples. To reduce the amount of incoming contaminants, several of the facilities have specifications that state "*Wood waste must be free of dirt, rocks, and metals*" or a similar statement. All of the firms using URW as a fuel, frequently observe shipments as they are unloaded and moved by conveyor. A supplier is warned if a significant amount of dirt, metal, plastic or paint is observed. If the supplier continues to provide poor quality feedstock, they are no longer allowed to bring URW to the facility. A few of the respondents have specifications for dirt and metals. One firm addresses this issue by allowing a maximum ash content of 90%.

Table 6: Contaminant Content (%) Specifications - Biomass Energy End Use								
Company	**Bark**	**OSB**	**MDF**	**Painted Wood**	**Treated Wood**	**Soil & Rocks**	**Metals**	**Plastics**
End User 1	nl	0	0	0	0	0	0	0
End User 2	nl	nl	nl	nl	0	0.5	0.5	0
End User 3	nl	0	0	0	0	0	0	0
End User 4	nl	nl	nl	0	0	0	0	0
End User 5	nl	0	0	0	0	a	a	0
End User 6	nl	nl	nl	b	0	c	c	0
End User 7	nl	nl	nl	0	0	0	0	0
End User 8	nl	nl	nl	nl	nl	0	0	0
End User 9	nl	0	0	0	0	0	0	0
End User 10	nl	nl	nl	0	0	0	0	0
End User 11	nl	nl	nl	d	0	0	0	0.5
End User 12	nl	nl	nl	0	0	0	0	0
End User 13	nl	0	0	0	0	0	0	0
End User 14	nl	e	e	e	0	1	1	1
Average	---	---	---	---	---	0.1	0.1	0.1
Std. Deviation	---	---	---	---	---	0.3	0.3	0.3
Maximum	nl	nl	nl	nl	nl	1	1	1
Minimum	---	0	0	0	0	0	0	0

nl - No limit
a - Soil, rocks, sand, and metal can be present, but ash content of fuel cannot exceed 10 %
b - Some non-lead paint might be acceptable
c - A minimum of soil, rocks, sand, and metal is desired, evaluated on a case by case basis
d - Limited to 10 % of the feedstock surface area
e - Unsure of acceptable level for this parameter
OSB - Oriented Strandboard
MDF - Medium density fiberboard

All of the respondents indicated that bark is acceptable and actually preferred, due to a higher BTU value. There are no brightness or species requirements. About half of the respondents allow wood with glue binders.

3.3 COMPOSITE WOOD MANUFACTURING

3.3.1 Summary

Twelve composite wood manufacturers supplied information on using URW as a manufacturing feedstock in composite wood products. Eighty-three percent of the respondents have used URW and 33% currently use URW for this purpose. Overall, the end users have experienced a number of difficulties using URW, mainly because of contaminants.

3.3.2 Issues Regarding Size and Shape

A finer textured feedstock is required for composite wood manufacturing than for biomass energy (Table 4). Two of the eleven respondents (18%) accept materials greater than two inches in length. The need for a finer textured feedstock reflects the historical use of fine-textured sawmill residuals (i.e. sawdust and shavings) as a composite wood manufacturing feedstock. Larger-sized materials have the most impact on materials conveyance. Conveyors were originally designed for fine-textured sawmill residuals. In general, suppliers have consistently met the URW size and shape specifications.

Table 7: Size and Shape Specifications - Composite Wood Manufacturing End Use

Company	Product	Dimensions (inches)			Overs	Fines Content		Shredded URW Acceptable ?
		Length	Width	Thick	Max (%)	Max (%)	Size (in.)	
End User 1	Hardboard	3.00	3.00	3.00	a	5	1/64	Yes
End User 2	Hardboard	1.00	0.75	0.25	5	5	1/4	Yes
End User 3	Hardboard	1.13	1.13	0.25	20	40	1/8	Yes
End User 4	Hardboard	0.38	0.38	0.38	0	b	b	Yes
End User 5	Softboard	2.00	2.00	0.75	5	5	1/8	No
End User 6	MDF	1.50	1.50	1.50	a	a	a	Yes
End User 7	PB	1.50	1.50	0.38	5	nl	---	Yes
End User 8	PB	3.00	1.50	0.13	2	nl	---	Yes
End User 9	PB	1.00	1.00	0.13	10	10	1/8	No
End User 10	PB	2.00	0.75	0.25	10	nl	---	Yes
End User 11	Hardboard	1.00	0.75	0.25	5	5	1/4	Yes
End User 12	PB, MDF	2.00	2.00	ns	20	2	1/8	Yes
Average		1.63	1.35	0.66	8.2	10.3	0.15	Yes (83%)
Std. Dev.		0.81	0.73	0.87	6.9	13.3	0.08	
Maximum		3.00	3.00	3.00	20.0	40.0	0.25	
Minimum		0.38	0.38	0.13	0	2.0	0.02	

MDF - Medium density fiberboard
PB - Particleboard
ns - Not specified
nl - No limit
a - Unsure of acceptable level for this parameter
b - Fines can cause dust problems, evaluated on a case by case basis

Each manufacturing facility has a varied tolerance to oversized feedstock. One mill indicated no tolerance for overs, while other mills accept feedstock with overs content of 5 to 20%.

In addition to affecting materials conveyance, some processes utilize a screening step in which overs are discarded as hog fuel or undergo additional size reduction. Again, the tolerance for fines varied. A few mills have no limit, while one mill accepts only 2%. The fines content is limited because the process and resulting product were designed to handle a specific mill waste with a minimum fines content.

With two exceptions, all of the mills indicated they could accept a shredded (as opposed to chipped) feedstock. Two mills cannot use shredded material because their facility is designed for handling either whole log chips or shavings. However, both mills have experimented with URW and the geometry of the feedstock was not mentioned as a problem.

3.3.3 Contaminant Issues

Contaminated URW is a significant issue for manufacturing composite wood products. All of the respondents who have tried or are currently using URW have experienced problems with contamination, particularly companies who make value-added, high-end products such as circuit boards. Several respondents indicated that the quality of the URW feedstock was inconsistent from load to load.

Contaminants like plastic, metal, and dirt, have a negative impact on the manufacturing process and the resulting product. Issues raised during the survey include:

- **Product safety and liability.** The presence of metal can cause injuries when the product is processed.
- **Product appearance.** Contaminants, especially plastics, can affect end-product appearance.
- **Product function.** Dirt and grit can cause excessive wear on power tools. The presence of metals in wood to be used as circuit boards can impact the operation of the resulting circuit board.

- **Manufacturing process.** Contaminants, particularly metals, cause sparks during conveyance and processing that can potentially start a fire. Contaminants also increase the wear on refining and other processing equipment.

Survey results indicate there is a low tolerance for contaminants in a composite wood manufacturing feedstock, especially dirt, metals, plastic, and painted and treated wood (Table 5). Some of the mills have contaminant removal equipment such as chip washers, screens, and air density separators. A few mills were considering the development of more sophisticated equipment and processes to clean up URW in the case of substantial increase in virgin fiber prices.

Table 8: Contaminant Content (%) Specifications – Composite Wood Manufacturing

Company	Bark	OSB	MDF	Painted Wood	Treated Wood	Soil & Rocks	Metals	Plastics
End User 1	18	nl	0	0	0	0	0	0
End User 2	0	25	0	0	0	0	0	0
End User 3	2	5	5	0	0	0	0	0
End User 4	2	0	0	0	0	0	0	0
End User 5	5	0	0	a	0	b	0	a
End User 6	0	0	0	0	0	0	0	0
End User 7	1	5	5	0	0	0	0	0
End User 8	0	0	0	0	0	0	0	0
End User 9	1	nl	nl	0	0	0	0	0
End User 10	0.8	nl	nl	0	0	0	0	0
End User 11	4	nl	nl	0	0	0	0	0
End User 12	1	10	2	0	0	1	1	0.001
Average	2.9	5.6	1.3	0	0	0.1	0.1	0
Std. Dev.	5.0	8.6	2.2	0	0	0.3	0.3	0
Maximum	18	25	5	0	0	1	1	0.001
Minimum	0	0	0	0	0	0	0	0

nl - No limit
a - Not certain of contamination limit, process and product quality might tolerate a very small amount of plastic and latex paint
b - Unsure of acceptable contaminant level, as facility has chip washing equipment
OSB - Oriented strandboard
MDF - Medium density fiberboard

Many of the mills could accept some quantity of wood with glue binders. Only 36% of the respondents could not accept plywood and 54% could not accept particleboard. One respondent indicated that wood particles covered with a glue resin (i.e. particleboard) do not bond well to glues and therefore, compromise product strength. Tolerance for bark, brightness, and tree species varied among the respondents. Three mills indicated no tolerance for bark, whereas the remainder could tolerate from 0.8 to 18%.

Three of the respondents indicated a light-colored wood feedstock was required (Table 6). Overall, the mills indicated they required softwood species and could not accept cedar. The varied restrictions on species type and the inability of URW processors to provide a known wood species does limit the amount of URW that can be used in a specific product.

Table 9: Moisture, Brightness, and Species Requirements – Composite Wood Manufacturing

Company	Moisture Content (%)		Brightness Requirement	Species Requirements
	Minimum	Maximum		
End User 1	50	90	No	Softwoods preferred, particularly douglas fir
End User 2	ns	Ns	No	No cedar or pine
End User 3	a	A	No	No cedar or hemlock
End User 4	30	60	No	Green douglas fir only
End User 5	ns	Ns	No	No juniper, cottonwood, or white fir
End User 6	ns	Ns	Yes	No cedar or redwood
End User 7	ns	Ns	Yes	None
End User 8	18	28	No	No pine, white fir; prefer douglas fir and hemlock
End User 9	5	60	No	No cedar; maximum 5% white fir
End User 10	10	12	Yes	No pine, white fir or spruce
End User 11	9	55	No	No cedar; maximum 10% douglas fir
End User 12	0	25	No	No cedar
Average	17	47	25% Yes	
Std. Dev.	17	27		
Maximum	50	90		
Minimum	0	12		

A - Can handle a wide range of moisture content
ns - Not specified

3.4 PULP AND PAPER MANUFACTURING

3.4.1 Summary

Nine pulp and paper mills supplied information. Seven of the nine mills (78%) have used URW as a pulp and paper making feedstock, however, only one-third are currently using this resource. As for the composite wood manufacturing industry, all of the mills that have tried or are currently using URW have experienced problems with contamination.

3.4.2 Issues Regarding Size and Shape

Survey results indicate that the pulp and paper industry requires the smallest and most consistently sized feedstock of the three end user categories evaluated (Table 7). This industry also has a lower tolerance for overs and fines than biomass energy and composite wood end use applications. Only two of the nine respondents (22%) accept feedstock greater than two inches in length or accept more than 5% overs. None of the mills accept more than 5% fines. The pulp and paper mill feedstock specifications reflect the use of whole log chips as a preferred feedstock. Mill residuals are the traditional, primary feedstock for these mills. However, due to competitive pressures, they are now aggressively seeking higher yields, new sources of fiber, and a preference for types of chips that are more consistent in size and shape than mill residuals.

Table 10: Size and Shape Specifications - Pulp and Paper Manufacturing End Use

Company	Product	Dimensions (inches)			Overs	Fines Content		Shred URW Acceptable ?
		Length	Width	Thick	Max (%)	Max (%)	Size (in.)	
End User 1	CM	2.50	2.50	0.38	5	5	1/8	Yes
End User 2	Phone book	1.00	1.00	0.13	5	2	3/16	No
End User 3	MP	0.88	0.88	0.39	5	5	1/8	Yes
End User 4	CM, CB	2.00	2.00	0.32	10	3	3/25	No
End User 5	UP, MP	1.00	1.00	0.28	5	5	3/16	Yes
End User 6	MP, BB, LB	1.00	1.00	0.19	3	3	1/8	No
End User 7	Newsprint	1.13	1.13	ns	5	1.5	3/16	Yes
End User 8	Newsprint	3.00	3.00	0.32	0.5	3	3/16	Yes
End User 9	Misc. paper	1.00	1.00	0.13	8	2	1/8	Yes
Average		1.50	1.50	0.26	5.2	3.3	0.15	Yes (67%)
Std. Dev.		0.79	0.79	0.11	2.7	1.4	0.03	
Maximum		3.00	3.00	0.39	10.0	5.0	0.19	
Minimum		0.88	0.88	0.13	0.5	1.5	0.12	

CM - Corrugated medium
CB - Container board
UP - Unbleached pulp
MP - Market pulp
BB - Bleached board
LB - Liner board

Like the other two end uses, material conveyance is an issue regarding feedstock size. Specifically, the feedstock size and consistency affects fiber recovery and pulp yield. Fiber recovery from a smaller-than-specified feedstock is poor. Inconsistent sized feedstocks "cook" at different rates, which also reduces fiber recovery. Three of the nine mills surveyed (33%) indicate that feedstock geometry is of significance and they prefer a “true chipped” type feedstock because this is more compatible with whole log chips, the primary manufacturing feedstock. One mill has been working with a URW processor to produce a chipped instead of shredded feedstock.

3.4.3 Contaminant Issues

Table 8 illustrates contaminant content specifications for the pulp and paper manufacturing firms. The presence of contaminants in URW is a significant issue for the pulp and paper industry because contaminants can significantly affect product quality. All the mills have had experience with this feedstock and indicated problems with contaminants. One of the respondents cited an example of a small piece of plastic lodged on a paper roller that caused an unacceptable line (blemish) on several hundred feet of paper. In addition to rendering the paper unusable, production time was lost finding and ameliorating the problem.

Table 11: Contaminant Content (%) Specifications - Pulp and Paper Manufacturing

Company	Bark	OSB	MDF	Painted Wood	Treated Wood	Soil & Rocks	Metals	Plastics
End User 1	5.0	0	0	0	0	1	1	0
End User 2	0.5	0	0	0	0	0	0	0
End User 3	0.5	0	0	0	0	0	0	0
End User 4	0.5	0	0	0	0	0	0	0
End User 5	0.5	0	0	0	0	0	0	0
End User 6	0.5	0	0	0	0	0	0	0
End User 7	0.2	0	0	0	0	0	0	0
End User 8	0.5	0	0	0	0	a	a	0
End User 9	4.0	0	0	0	0	0	0	0
Average	1.4	0	0	0	0	0.1	0.1	0
Std. Dev.	1.8	0	0	0	0	0.4	0.4	0
Maximum	5.0	0	0	0	0	1	1	0
Minimum	0.2	0	0	0	0	0	0	0

A - Unsure of acceptable contaminant level, as facility has chip washing equipment
OSB - Oriented strandboard
MDF - Medium density fiberboard

The presence of dirt and unacceptable wood species can have a negative effect on brightness. This is an issue for two-thirds of the mills contacted (Table 9). Several mills are restrictive in the species they can handle, which makes it difficult to use URW as a manufacturing feedstock. Contaminants can also have a negative effect on equipment and the manufacturing process. For instance, grit and metal can cause excessive wear on refiner plates and other processing equipment.

Table 12: Moisture, Brightness and Species Requirements - Pulp and Paper Manufacturing

Company	Moisture Content (%)		Brightness Requirement	Species Requirements
	Minimum	Maximum		
End User 1	nl	nl	No	No Cedar
End User 2	A	ns	Yes	Hemlock and spruce only
End User 3	ns	ns	Yes	Hemlock and white fir only
End User 4	ns	ns	No	Hardwood only for corrugated medium
End User 5	ns	ns	Yes	Conifer only
End User 6	B	ns	Yes	Hardwoods excluded from market pulp
End User 7	C	ns	Yes	Only true firs: hemlock, white, grand, noble, silver
End User 8	ns	ns	Yes	< 15% hardwoods
End User 9	ns	ns	No	None
Average	---	---	Yes (67%)	
Std. Dev.	---	---		
Maximum	---	nl		
Minimum	Nl	---		

A - Mechanical process requires green wood, low moisture content wood does not work well
B - Can't be too dry
C - No kiln dried wood
nl - No limit
ns - Not specified

Several of the mills recognize the potential of URW. Urban recycled wood represents an available and cost-effective source of fiber. Consequently, these mills have worked closely with some of the URW processors to provide a clean and consistent supply. Some mills have certain equipment, such as chip washers, for cleaning up the feedstock at the mill. Others are considering more sophisticated, on-site contaminant removal systems.

4.0 URBAN RECYCLED WOOD CHARACTERIZATION RESULTS

4.1 URBAN RECYCLED WOOD PROCESSING FACILITY DESCRIPTIONS

4.1.1 Facility 1

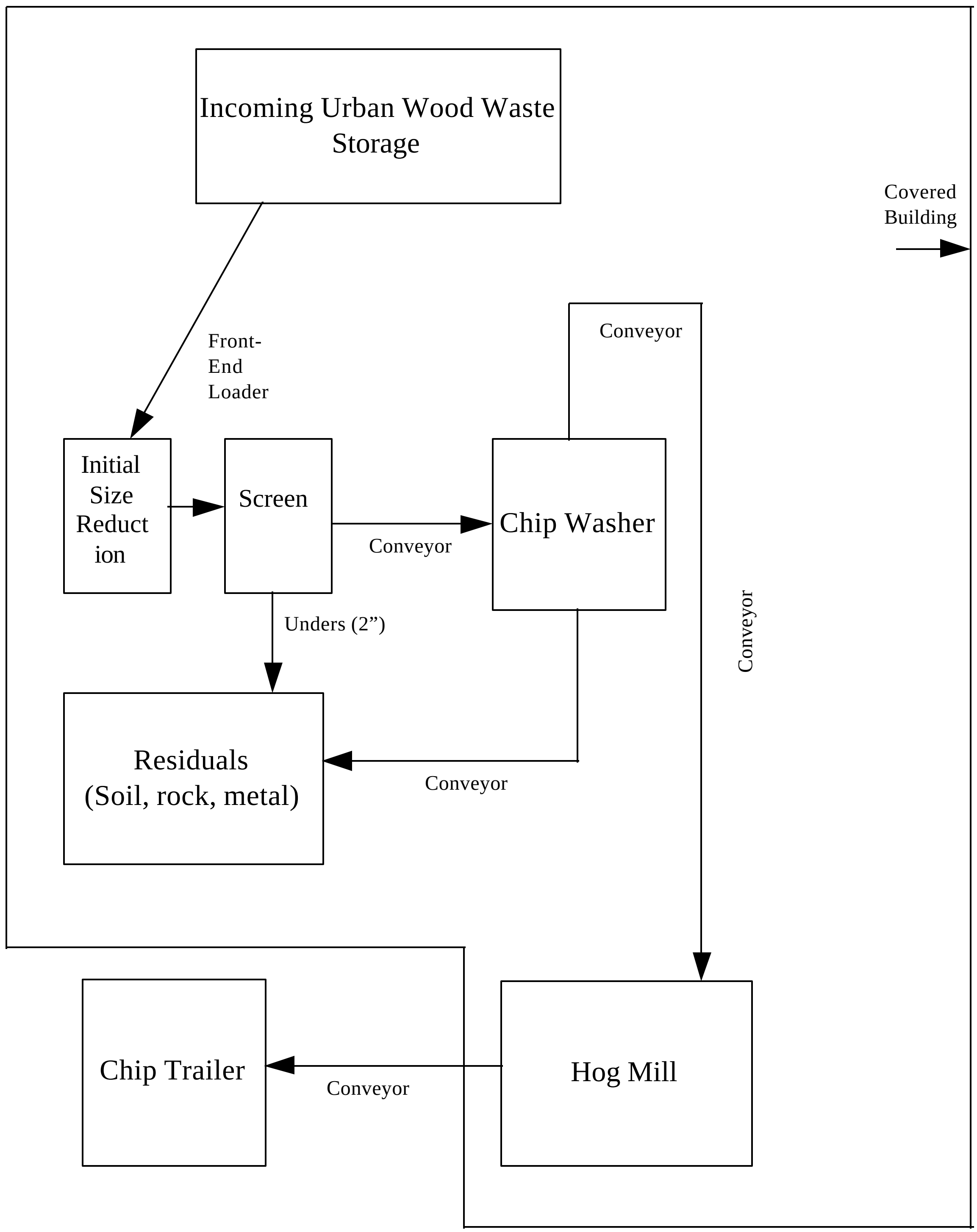
Facility 1 processes approximately 180,000 tons of urban wood debris annually. Demolition debris comprises about 70% of this material (Table 10). The remaining wood debris processed is cleaner material such as pallets and mill ends. This facility is also involved with building demolition and hauling of the building demolition debris, which allows for a higher degree of control over the incoming feedstock. The demolition workers are trained in what materials are acceptable for the wood debris processing facility. Some material is also brought to the facility through other haulers. All of the URW processed is used as a biomass energy fuel.

Table 13: Facility 1 Overview	
Facility throughput	• 180,000 tons per year
Materials processed	• 70% wood frame building demolition debris • 15% clean URW (pallets) • 15% industrial wood debris (mill ends, framing etc.)
Collection and transfer	• Most material is collected and hauled by the facility • Some material brought into facility by other haulers
Contaminant removal	• Train demolition workers on acceptable materials • Charge higher fee for contaminated loads • Pull out some contaminants by hand prior to processing • Process train includes a chip washer to remove rocks & metals
Process rejects disposed	• Approximately 8 to 10 % of incoming material
End markets	• Biomass energy

Incoming loads at Facility 1 are unloaded onto a concrete floor and inspected for contaminants. Some large-sized contaminants are manually removed prior to processing. A hauler not affiliated with the facility may be charged a higher tipping fee if a load has excessive contamination.

Material received at Facility 1 is prepared for market through the process train depicted in Figure 2. Incoming material is initially fed into a large metal box equipped with an auger on the bottom. The auger pushes the URW through a small opening that crushes and tears large dimensional lumber into smaller pieces that are more readily conveyed through the process. After the initial size reduction step, the URW is passed over a vibrating deck screen equipped with two-inch holes, removing the undersized fraction which contains a considerable quantity of grit, soil, rocks, and metal. A chip washer further removes grit, rocks, metal, and other materials that do not float. The resulting material is then fed into a hog mill for size reduction. The finished product is then conveyed to a chip truck. The entire process, including incoming material storage, is conducted undercover.

Figure 2 - Facility 1 Processing Schematic



4.1.2 Facility 2

Facility 2 processes approximately 50,000 tons of urban wood debris annually (Table 11). The facility only accepts “clean” urban wood debris. About one-half is comprised of pallets and crates, 40% is clean wood from industrial and commercial sources, and 10% is urban wood debris separated from municipal recycling facilities. Half of the incoming material is hauled by the facility and the remaining is hauled by wood debris generators and commercial haulers. The clean nature of the incoming feedstock is reflected in the small amount of material disposed as refuse (less than 1%). The primary product produced is a pulp and paper manufacturing feedstock. Screen unders (less than 3/8”) are marketed as a biomass fuel.

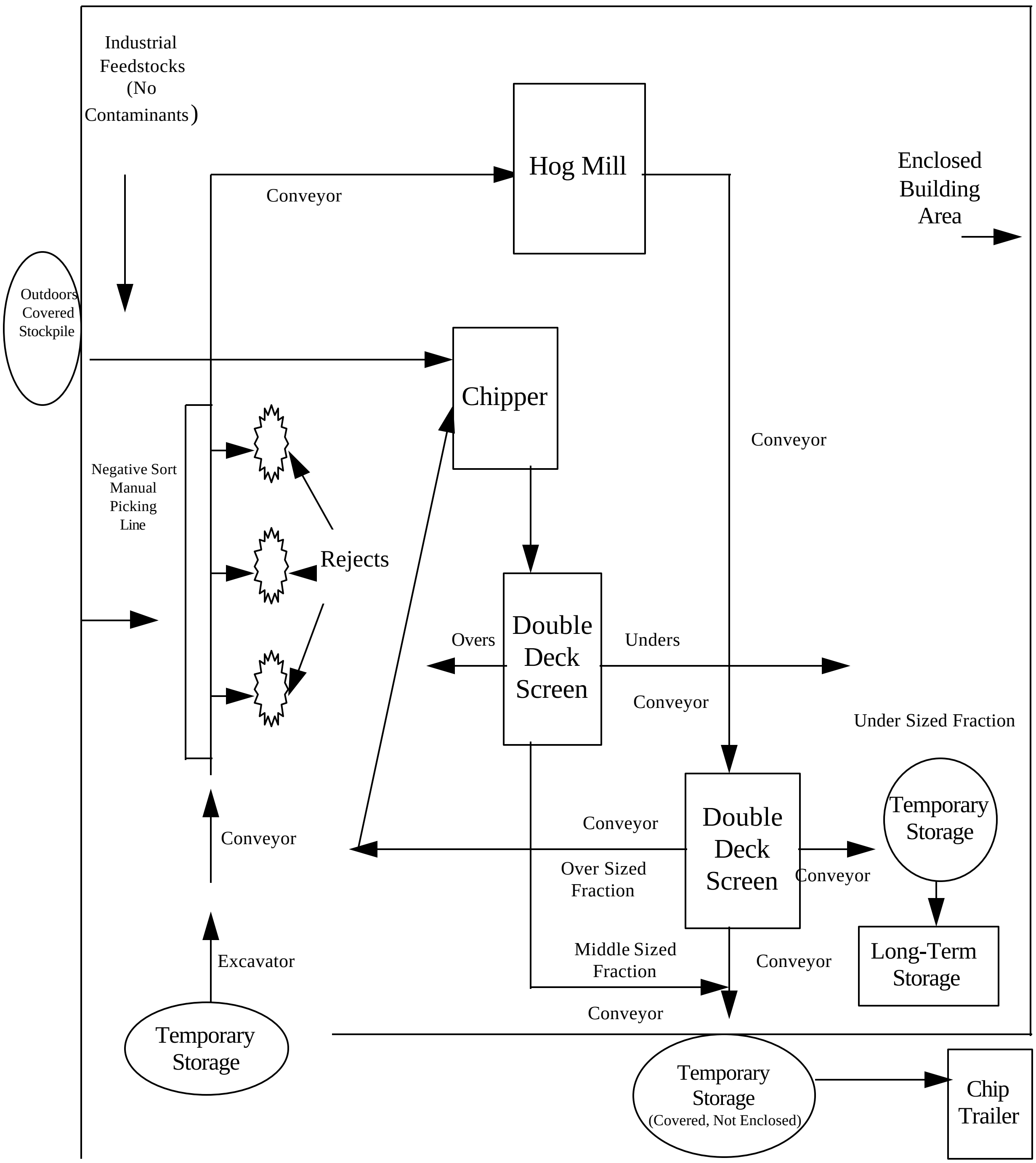
Table 14: Facility 2 Overview

Facility throughput	• Approximately 50,000 tons per year
Materials processed	• 50% pallets and crates • 40% clean wood from commercial and industrial sources • 10% wood debris separated from municipal recycling facilities
Collection and transfer	• 50% hauled from source by Facility 2 • 35% hauled by wood debris generators • 15% hauled by commercial waste haulers
Contaminant removal	• Only accept clean materials • Loads are inspected for contaminants • Pick line for manual contaminant removal • Magnets in process train for ferrous metal removal • Manual removal of contaminants from URW stockpile
Process rejects disposed	• < 1 %
End markets	• Pulp and paper manufacturing feedstock • Biomass fuel (screen unders)

Facility 2 provides a list of acceptable and unacceptable materials to customers. Incoming loads at the facility are unloaded onto a concrete slab and inspected for contaminants. Contaminated loads are subjected to a surcharge or rejection. After initial inspection, loads of incoming material are either placed in stockpiles or are fed into the process.

The process used at Facility 2 to prepare urban wood debris for market is presented in Figure 3. Material is fed into the process by way of a track-mounted excavator. The excavator also serves to breakup large dimensional lumber into smaller pieces that are more readily conveyed through the system. The material then goes past a manual picking line where non-metal contaminants

Figure 3 - Facility 2 Processing Schematic



such as plastic, styrofoam, roofing material, composite wood, and other contaminants are removed. After the picking line, the material is size-reduced in a hog mill equipped with a fine-spray water mister to keep minimize dust levels. Finally, the material is passed through a double-deck screen fitted with 1-3/4 inch and 5/16 inch round hole screens.

The unders are segregated and sold primarily as a biomass fuel. The overs are moved back into the system and are passed through a chipper and a similar double deck screen. The middle fraction (between 5/16 and 1-3/4 inch) is conveyed to a storage pile where an employee manually removes plastic film and any other visible contaminants. This middle fraction is marketed as a paper manufacturing feedstock. After the grinding process, five magnets in the process train remove ferrous metals. The entire facility is enclosed, with the exception of the incoming URW stockpiles.

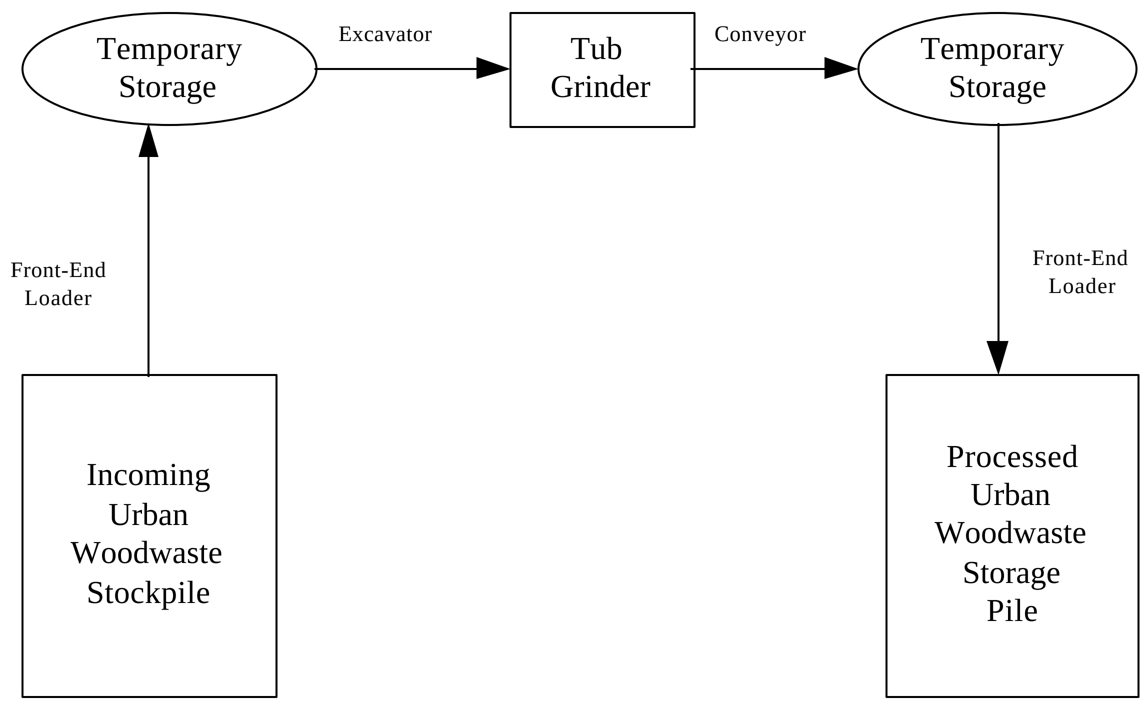
4.1.3 Facility 3

Facility 3 processes approximately 40,000 cubic yards of URW annually (Table 12). The facility accepts a variety of materials, including land clearing debris, demolition debris, and pallets and other clean wood. This facility accepts materials with a higher level of contamination than manufacturing end uses, since the primary end use is biomass fuel. The material is brought to the facility by commercial haulers and commercial entities that haul their own wood debris. Residential hauled loads comprise approximately 25% of the incoming material. Facility 3 has successfully marketed products comprised of land clearing debris as animal bedding and landscaping products.

Table 15: Facility 3 Overview	
Facility throughput	• 40,000 cubic yards per year
Materials processed	• 50% relatively clean wood (some painted wood) from residential, commercial, and industrial sources • 30% land clearing debris • 20% demolition debris
Collection and transfer	• 40% commercial hauler • 35% hauled by commercial generators • 25% residential self haul
Contaminant removal	• Loads are inspected for contaminants • Higher tip fees for contaminated loads • Manual removal of gross contaminants
Process rejects disposed	• Approximately 1 % of incoming material
End markets	• 75% biomass fuel • 25% animal bedding and landscaping

Facility 3 uses a simple process, as illustrated in Figure 4. Incoming material is placed in a large stockpile on an asphalt surface. Material to be processed is pushed with a front-end loader into a temporary stockpile and then loaded with an excavator into the tub grinder. Processed material is periodically pushed up into a large storage pile, which due to its size, sheds water reasonably well. The entire facility is uncovered and exposed to outdoor conditions.

Figure 4 - Facility 3 Processing Schematic



* Facility 3 is not covered.

4.1.4 Facility 4

Facility 4 differs from the other three facilities because it only removes clean URW from loads that contain wood and varying amounts of contaminants. The clean wood debris is then transferred to Facility 2 for processing. Facility 4 is in the process of developing a separate URW processing facility. In this project, several loads (a total of approximately 200 cubic yards) were transferred to the proposed facility site where the material was ground with a tub grinder to produce samples for analysis.

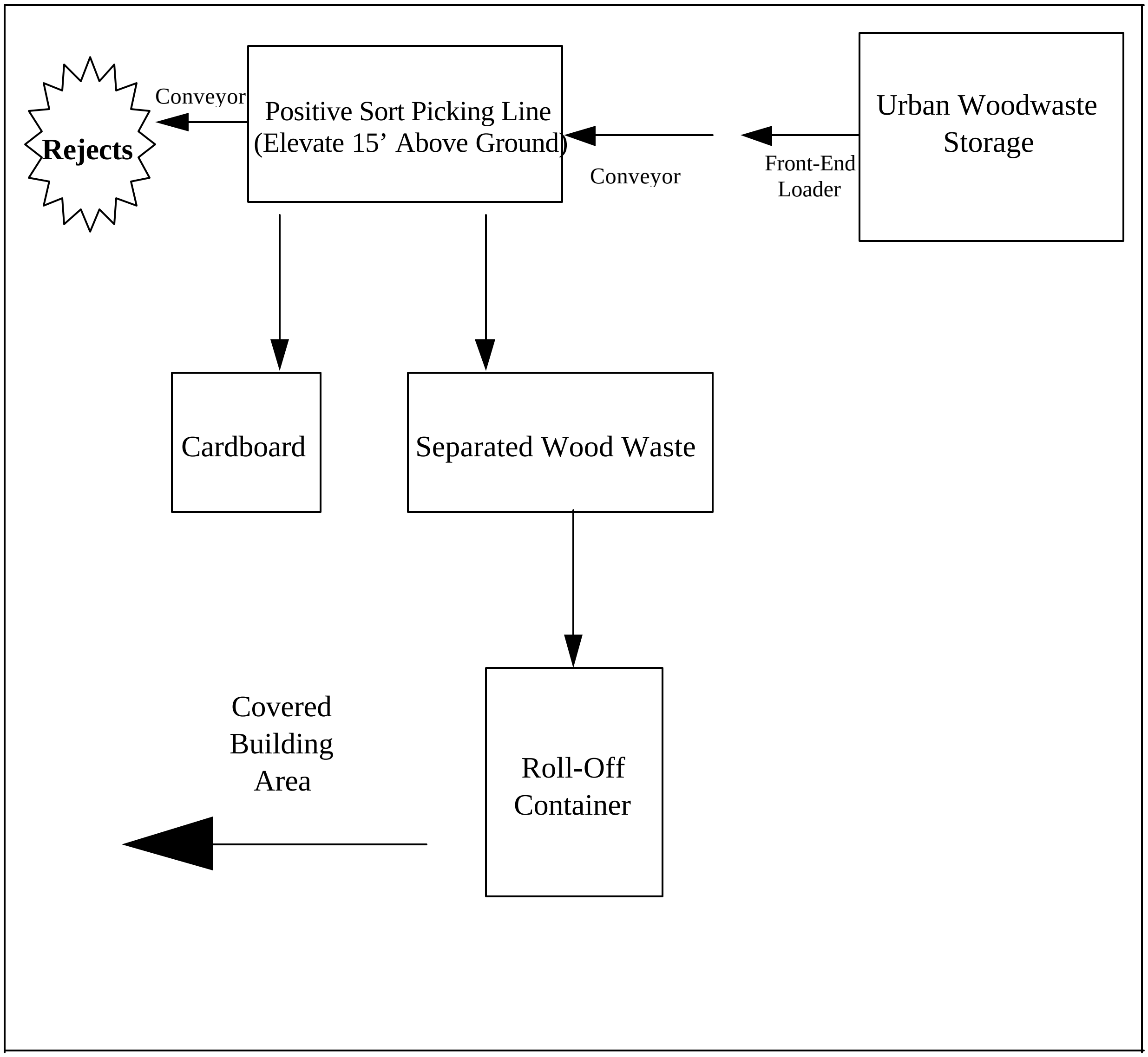
Facility 4 processes approximately 17,000 tons of urban wood debris annually (Table 13). The wood debris is obtained from an assortment of customers and contains varying degrees of contamination. The tipping fee rate structure has three different categories and is based on the amount of contamination. Approximately 75% of the incoming material has a high amount of contamination (painted wood, refuse, plastic, etc.), as evidenced by the high fraction of material disposed in a landfill. About 85% of the material received is hauled by the company. The remaining 15% is hauled by contractors and other firms that actually generate the wood debris.

Table 16: Facility 4 Overview

Facility throughput	• Approximately 17,000 tons per year
Materials processed	• 75% mixed URW mixed with some refuse • 15% semi-clean wood , some contaminants some refuse • 10% clean (no contaminants, painted wood, etc.) URW
Collection and transfer	• 85% by facility hauling company • 15% self-haul by URW generators
Contaminant removal	• Primarily through a pick line
Process rejects disposed	• Approximately 60% of incoming material
End markets	• Material is brought to Facility 2 where it is processed

The high grading process used by Facility 4 is presented in Figure 5. Incoming loads are stored temporarily on one side of the building on a concrete surface. A front-end loader is used to introduce the material onto a conveyor that passes the material onto a positive sort pick line. At the pick line, which is 15 feet above from the floor, clean urban wood without paint is manually pulled out and dropped down chutes in the pick line to the floor. The segregated clean urban wood is placed in drop boxes and hauled to the processing facility.

Figure 5 - Facility 4 Processing Schematic



4.2 CHARACTERIZATION RESULTS

4.2.1 Facility 1

Biomass Energy End Use

URW characterization results for biomass fuel from demolition debris produced by Facility 1 is presented in Table 14. Facility 1 does not produce feedstock for the composite wood or paper manufacturing industries. Despite the use of a chip washer in the process train, this product has total solids content similar to the biomass fuel and high value products produced by the other facilities. The short detention time in the washer and the large size of the material results in a small amount of water absorption. This product has the highest energy content of the three biomass fuels analyzed.

Trace metals analysis indicated that a few of the metals were at elevated levels. This product had an average lead concentration of 100 parts per million (ppm) and an average arsenic concentration of 20 ppm. Paint from older buildings is a likely source of the lead and treated wood is a probable source of the arsenic. Elevated trace metals did not have an impact on using the product as a biomass fuel.

Sieve analysis indicates that this product is within the biomass fuel specifications presented in Section 3. Approximately 9% of the product is greater than three inches in size, with only 24% being greater than one inch. It is not anticipated that this product would cause any conveyance problems. It should not create an excessive dust problem when handled because only 0.7% of the product passes a 1/25 inch sieve and 11% passes a 3/16 inch sieve.

This product had considerable contamination, which is acceptable for its end use as a fuel at a state of the art burn facility. However, some of the categories such as composite wood and paper and cardboard should not be considered contaminants for this end use. No treated wood or ferrous metals were found in the samples analyzed. On average, the product contained approximately 1.2% painted wood, 0.05% plastic, and 0.15% roofing material. The contaminant content is low considering the source of this material is demolition debris.

Table 17: Facility 1 URW Characterization Results (Biomass Energy End Use)

Analytical Parameter	Units	Sample 1 9-16-96	Sample 2 10-25-96	Sample 3 11-22-96	Sample 4 12-12-96	Average (Std. Dev.)
Chemical & Physical Characteristics						
Total solids	%	61.1	74.0	70.2	70.5	69.0 (5.5)
Volatile solids	%	93.0	98.3	97.6	97.2	96.5 (2.4)
Bulk density	lb/cy	433	385	349	368	384 (36)
Energy value *	BTUs/lb	6,440	6,350	7,030	6,140	6,490 (381)
Brightness	rating	4	4	4	4	4.0 (0)
Arsenic	mg/kg	6.0	46.1	2.6	26.4	20.3 (20.2)
Cadmium	mg/kg	nd	0.3	0.6	0.3	0.3 (0.2)
Chromium	mg/kg	7.0	47.0	9.6	33.9	24.4 (19.3)
Copper	mg/kg	12.0	32.9	6.9	22.6	18.6 (11.6)
Lead	mg/kg	84.0	72.2	120.0	123.0	99.8 (25.5)
Nickel	mg/kg	nd	3.1	2.4	2.0	1.9 (1.3)
Zinc	mg/kg	177.0	88.9	118.0	176.0	140.0 (43.8)
Sieve Analysis (% passing sieve)						
< 3 inch (76.2 mm)	%	90.7	90.6	92.6	91.2	91.3
1 inch (25.4 mm)	%	73.0	75.1	81.2	74.9	76.1
5/8 inch (15.9 mm)	%	55.9	59.9	65.4	60.0	60.3
3/8 inch (9.5 mm)	%	24.0	35.3	39.7	35.5	33.6
5/16 inch (7.9 mm)	%	18.4	26.8	29.8	26.1	25.3
3/16 inch (4.75 mm)	%	9.8	11.8	12.5	8.9	10.8
1/25 inch (1.0 mm)	%	0.5	0.8	1.0	0.6	0.7
Inert Contaminant Content						
Rocks	%	nf	nf	nf	0.01	< 0.01
Sand and dirt	%	5.00	nd	0.40	0.80	1.48 (2.39)
Ferrous metal	%	0.37	0.21	0.43	0.33	0.34 (0.09)
Non-ferrous metal	%	nf	nf	nf	nf	nf
Total composite	%	0.73	9.69	6.36	10.89	6.92 (4.55)
Plywood	%	0.34	4.25	5.01	2.77	3.09 (2.06)
Particleboard	%	0.34	1.25	0.79	2.04	1.10 (0.73)
Oriented strand brd.	%	9.06	4.19	0.56	6.07	2.72 (2.89)
Plastics	%	0.06	0.01	0.13	0.01	0.05 (0.06)
Total painted wood	%	2.51	0.47	1.25	0.41	1.16 (0.98)
Pre-consumer paint	%	0.03	0.05	nf	0.02	0.03 (0.02)
Post-consumer paint	%	2.48	0.42	1.25	0.39	1.13 (0.98)
Treated wood	%	nf	nf	nf	nf	nf
Paper/cardboard	%	nf	0.01	0.17	0.05	0.06 (0.08)
Roofing material	%	0.77	0.08	0.89	0.15	0.47 (0.42)
Foam rubber	%	0.27	nf	0.04	0.01	0.08 (0.13)
Styrofoam	%	0.01	nf	0.01	0.01	0.01 (0.01)

Total solids = 100 - moisture content
Total composite = plywood + particle board + OSB
Total painted wood = pre-consumer paint + post-consumer paint

***Energy value is BTU's per green lb. of product**
nd - Analyte was not detected
nf - Specific contaminant type was not found

4.2.2 Facility 2

Biomass Energy End Use

Characteristics of the biomass fuel generated by Facility 2 are presented in Table 15. The facility processes clean URW containing a minimal amount of contamination. The biomass fuel product is the fines fraction that results from the production of a paper manufacturing feedstock. The biomass fuel product has a low moisture content (approximately 30%) that is similar to the other two fuels analyzed. The high volatile solids (low ash) content is an indication that this product contains a small amount of sand and dirt. The average energy content of 5,800 BTUs per green pound is greater than that of Facility 3, but less than Facility 1. The trace metal content is very low, which is a reflection of the clean URW processed by this facility. This product was not analyzed for contaminants but none were observed in the product.

Table 18: Facility 2 URW Characterization Results (Biomass Energy End Use)

Analytical Parameter	Units	Sample 1 9-19-96	Sample 2 9-27-96	Sample 3 1-2-97	Sample 4 1-22-97	Average (Std. Dev.)
Chemical & Physical Characteristics						
Total solids	%	73.9	79.1	59.0	72.4	71.1 (8.6)
Volatile solids	%	98.5	98.2	99.5	98.1	98.6 (0.6)
Bulk density	lb/cy	395	375	383	375	382 (9.2)
Energy value*	BTUs/lb	5,900	6,560	5,140	5,810	5,853
Brightness	rating	4	4	4	4	4.0 (0)
Arsenic	mg/kg	2.2	4.8	nd	1.6	2.2 (2.0)
Cadmium	mg/kg	0.2	0.2	0.04	0.2	0.1 (0.1)
Chromium	mg/kg	3.9	9.6	1.2	6.4	5.3 (3.6)
Copper	mg/kg	11.6	80.0	1.5	16.0	27.3 (35.7)
Lead	mg/kg	7.8	9.1	13.8	7.5	9.5 (2.9)
Nickel	mg/kg	1.6	3.9	0.8	4.3	2.7 (1.7)
Zinc	mg/kg	35.8	52.0	47.2	39.4	43.6 (7.3)
Sieve Analysis (% passing sieve)						
< 3 inch (76.2 mm)	%	100	100	100	100	100
1 inch (25.4 mm)	%	100	100	100	99.9	100
5/8 inch (15.9 mm)	%	100	100	99.2	99.7	99.7
3/8 inch (9.5 mm)	%	99.7	99.7	81.1	97.8	94.6
5/16 inch (7.9 mm)	%	99.2	99.2	75.3	95.8	92.4
3/16 inch (4.75 mm)	%	87.2	83.5	41.2	80.2	73.0
1/25 inch (1.0 mm)	%	13.0	13.2	3.9	11.0	10.4

Total solids = 100 - moisture content **Energy value is BTU's per green lb. of product**
nd - Analyte was not detected

As indicated by the sieve analysis, this product has fine, sawdust-like texture with more than 90% passing a 5/16-inch sieve. Consequently, this material should not cause any conveyance problems. A relatively large fraction, about 10%, passes a 1/25-inch screen. The use of this material as a biomass fuel could create dust conditions.

Manufacturing End Use

Table 16 represents the characteristics of a paper manufacturing feedstock produced by Facility 2. This product is dry with an average total solids content of 76% (24% moisture content). The high volatile solids content and low brightness rating are a reflection of the clean incoming URW and sophisticated process train.

Sieve analysis indicates that this product has a uniform size in relation to other products analyzed, with 85% of the product passing a one-inch sieve and only 20% passing a 5/16-inch sieve. Therefore, an average of 65% of the product has dimensions between one inch and 5/16-inch in size. Size and shape specifications for the pulp and paper manufacturing industry (Table 7) indicate five of the nine facilities require a product that is one inch or less in width and length dimensions, and allow an overs fraction of 5 to 10%. With about 15% of the product greater than one inch in size, some paper mills could potentially experience some difficulties with the conveyance of this material.

However, paper mills specify that paper manufacturing feedstocks can have a 1.5 to 5% fines content less than 1/8 to 3/16-inch in size (Table 7). The fines content of the Facility 2 product is slightly elevated, with an average of about 8% passing a 3/16-inch sieve. This product should not create dust conditions, since less than 1% passes a 1/25-inch sieve.

The contaminant analysis indicates this product contains a small quantity of contaminants. With the exception of composite wood materials, the average concentration of the other contaminants was under 0.1%. Plastic is the contaminant that has the greatest impact on the paper making process per unit weight and was found at a concentration of 0.01 %.

Table 19: Facility 2 URW Characterization Results (Manufacturing End Use)						
Analytical Parameter	Units	Sample 1 9-19-96	Sample 2 9-27-96	Sample 3 1-2-97	Sample 4 1-22-97	Average (Std. Dev.)
Chemical & Physical Characteristics						
Total solids	%	78.5	88.9	63.9	73.1	76.1 (10.4)
Volatile solids	%	99.4	99.5	99.4	99.4	99.4 (0.1)
Bulk density	lb/cy	363	346	385	407	375 (27)
Brightness	rating	2	2	2	2	2.0 (0)
Sieve Analysis (% passing sieve)						
< 3 inch (76.2 mm)	%	99.0	96.5	97.6	98.1	97.8
1 inch (25.4 mm)	%	88.7	88.1	75.6	88.9	85.3
5/8 inch (15.9 mm)	%	69.5	77.2	52.6	67.9	66.8
3/8 inch (9.5 mm)	%	34.0	25.5	26.0	33.2	29.7
5/16 inch (7.9 mm)	%	24.9	17.3	18.1	21.1	20.3
3/16 inch (4.75 mm)	%	12.2	4.9	7.4	8.6	8.3
1/25 inch (1.0 mm)	%	1.5	0.1	1.0	0.6	0.8
Inert Contaminant Content						
Rocks	%	0.01	0.02	0.01	0.03	0.02 (0.01)
Sand and dirt	%	nd	nd	nd	nd	nd
Ferrous metal	%	nf	Nf	nf	nf	nf
Non-ferrous metal	%	< 0.01	Nf	nf	nf	nf
Total composite	%	0.41	0.92	1.06	1.75	1.04 (0.55)
Plywood	%	0.20	0.58	0.75	1.41	0.74 (0.50)
Particleboard	%	0.07	0.13	0.08	0.14	0.10 (0.03)
Oriented strand brd.	%	0.13	0.21	0.23	0.20	0.19 (0.04)
Plastics	%	0.02	0.005	0.003	0.004	0.01 (0.01)
Total painted wood	%	0.03	0.10	0.06	0.11	0.07 (0.04)
Pre-consumer paint	%	0.02	0.06	0.06	0.11	0.06 (0.04)
Post-consumer paint	%	0.01	0.04	nf	nf	0.01 (0.02)
Treated wood	%	nf	nf	nf	nf	nf
Paper/cardboard	%	0.04	0.03	0.01	0.01	0.02 (0.01)
Roofing material	%	nf	0.01	0.01	0.01	0.01 (0.01)
Foam rubber	%	nf	nf	nf	nf	nf
Styrofoam	%	nf	nf	nf	nf	nf

Total solids = 100 - moisture content
Total composite = plywood + particle board + oriented strand board
nf - Specific contaminant type was not found
Total painted wood = pre-consumer paint + post -consumer paint

The average total composite wood content was about 1%. The primary concern regarding this contaminant is the non-water soluble glues used in many composite wood products. However, given the small percentage of this product used in the paper making process, the amount of composite wood in this product does not appear to be an issue in its current end use application.

4.2.3 Facility 3

Biomass Energy End Use

Facility 3 accepts a wide variety of URW, including composite wood, woody yard debris, and some painted wood and demolition debris and only produces a biomass fuel product. In addition to obtaining a sample of the biomass fuel product, this facility also produced a higher quality product specifically to test in this project. Production aspects of this high value product are discussed later in this section.

The characteristics of the biomass fuel product produced by Facility 3 are presented in Table 17. This product has a total solids content of 65% (35% moisture content). It has a slightly lower total solids content than the other biomass fuel products (approximately 70%), apparently because the facility is uncovered. The lower energy content may also be caused by the product having a slightly lower total solids content than the other biomass fuel products. This product also has a lower volatile solids content than the other biomass fuels analyzed and could be a result from processing woody yard debris, which contains more sand and dirt than other URW. The contaminant content of this product was not determined, but observations indicate a large concentration of painted and composite wood products. The end-user can accept and burn URW that contains paint wood.

The particle size of this product is appropriate for use as a biomass fuel and should not cause any conveyance problems. Only 5% of the product is greater than three inches in size and approximately 3% of the product passes a 1/25-inch screen. The small particle size of this product could potentially create a dust problem if improperly handled.

A few trace metals have elevated levels in Facility 3, which primarily accepts demolition debris. In particular, arsenic and lead concentrations are greater than those of wood that does not include painted wood and demolition debris. The elevated trace metals do not have a negative impact on the facilities using this material as a fuel.

Table 20: Facility 3 URW Characterization Results (Biomass Energy End Use)						
Analytical Parameter	Units	Sample 1 10-16-96	Sample 2 11-14-96	Sample 3 1-22-97	Sample 4 2-7-97	Average (Std. Dev.)
Chemical & Physical Characteristics						
Total solids	%	54.0	73.6	61.4	72.6	65.4 (9.4)
Volatile solids	%	96.9	97.5	96.3	96.7	96.9 (0.5)
Bulk density	lb/cy	351	383	378	351	366 (17)
Energy value *	BTUs/lb	4,450	6,020	5,100	5,500	5,268 (662)
Brightness	Rating	4	4	4	4	4.0 (0)
Arsenic	mg/kg	33.3	192.0	36.8	46.3	77.1 (77)
Cadmium	mg/kg	0.3	0.2	0.5	0.2	0.3 (0.1)
Chromium	mg/kg	43.7	225.0	56.8	61.6	96.8 (86)
Copper	mg/kg	33.9	156.0	26.1	38.1	63.5 (62)
Lead	mg/kg	87.2	72.8	576.0	39.5	193.9 (256)
Nickel	mg/kg	1.0	1.5	1.8	2.4	1.7 (0.6)
Zinc	mg/kg	235.0	158.0	450.0	212.0	264 (128)
Sieve Analysis (% passing sieve)						
< 3 inch (76.2 mm)	%	98.0	93.8	93.9	96.8	95.6
1 inch (25.4 mm)	%	81.6	67.3	81.5	78.4	77.2
5/8 inch (15.9 mm)	%	63.0	50.7	64.7	62.6	60.2
3/8 inch (9.5 mm)	%	38.0	32.0	42.9	39.5	38.1
5/16 inch (7.9 mm)	%	29.8	25.8	35.1	33.1	30.9
3/16 inch (4.75 mm)	%	15.4	15.2	20.2	17.9	17.2
1/25 inch (1.0 mm)	%	1.4	2.9	2.4	3.9	2.6

Total solids = 100 – moisture content
*** BTU's per green pound**

Manufacturing End Use

Table 18 represents characteristics of the manufactured end product Facility 3. As discussed previously, this product was manufactured specifically for this project. On four different occasions, approximately 100 cubic yards of clean wood was separated manually from the main stockpile of incoming URW and was ground in a tub grinder and separated. Several years ago, during a more favorable economic setting, this facility produced a high value product for use as a composite wood manufacturing feedstock using a similar process (Figure 4).

Table 21: Facility 3 URW Characterization Results (Manufacturing End Use)						
Analytical Parameter	Units	Sample 1 10-16-96	Sample 2 11-14-96	Sample 3 1-22-97	Sample 4 2-7-97	Average (Std. Dev.)
Chemical & Physical Characteristics						
Total solids	%	85.0	70.3	68.6	65.5	72.4 (8.6)
Volatile solids	%	98.9	97.8	96.7	99.5	98.2 (1.2)
Bulk density	lb/cy	324	383	353	383	361 (28)
Brightness	rating	2	2	2	2	2.0 (0)
Sieve Analysis (% passing sieve)						
< 3 inch (76.2 mm)	%	93.6	95.1	97.9	92.9	94.9
1 inch (25.4 mm)	%	82.2	70.5	84.0	76.4	78.2
5/8 inch (15.9 mm)	%	68.5	51.8	69.7	56.8	61.7
3/8 inch (9.5 mm)	%	38.8	29.9	45.5	32.6	36.7
5/16 inch (7.9 mm)	%	29.9	22.8	37.2	25.0	28.7
3/16 inch (4.75 mm)	%	15.3	11.0	14.1	11.7	13.0
1/25 inch (1.0 mm)	%	2.0	1.0	2.1	0.9	1.5
Inert Contaminant Content						
Rocks	%	0.01	nf	nf	nf	< 0.01
Sand and dirt	%	nd	1.20	2.30	nd	0.88 (1.11)
Ferrous metal	%	nf	nf	nf	nf	nf
Non-ferrous metal	%	nf	nf	nf	nf	nf
Total composite	%	10.41	15.85	19.13	0.56	11.49 (8.12)
Plywood	%	6.70	5.82	3.30	0.18	4.00 (2.93)
Particleboard	%	0.72	0.33	2.03	0.07	0.79 (0.87)
Oriented strand brd.	%	3.00	9.70	13.81	0.31	6.70 (6.16)
Plastics	%	nf	0.01	0.04	nf	0.01 (0.02)
Total painted wood	%	1.22	0.90	0.06	0.09	0.57 (0.58)
Pre-consumer paint	%	0.21	0.03	nf	0.07	0.08 (0.09)
Post-consumer paint	%	1.01	0.87	0.06	0.02	0.49 (0.52)
Treated wood	%	nf	nf	nf	nf	nf
Paper/cardboard	%	nf	nf	0.02	nf	0.01 (0.01)
Roofing material	%	0.04	nf	nf	nf	nf
Foam rubber	%	nf	nf	nf	nf	nf
Styrofoam	%	nf	nf	nf	nf	nf

Total solids = 100 - moisture content
Total composite = plywood + particle board + oriented strand board
nf - Specific contaminant type was not found

The average total solids and volatile solids content and brightness of this product are similar to that of the other manufacturing end use products, indicating a dry product with a low dirt and sand content. Sieve analysis of this product is similar to the biomass fuel product, since both products are processed using the same tub grinder. This particle size distribution is acceptable for a biomass fuel, but based on the specifications presented in Section 3, contains an excessive overs and fines fraction.

Contaminant content varies between the four different samples and a result of the pilot process development of this sample. For example, the plywood concentration varied from a high of 6.70% to a low of 0.18%. The concentration of all composite wood materials varied considerably between samples. Plastic, the most significant contaminant, was found at a very low concentration of only 0.01%. None of the samples contained rocks, ferrous, and non-ferrous metals, treated wood, or roofing material. In addition to the composite wood materials, painted wood was the major contaminant in this product and was found at approximately 0.5 %.

4.2.4 Facility 4

Manufacturing End Use

The characteristics of a manufacturing end use product from Facility 4 are presented in Table 19. Using a positive sort picking line, this facility manually separates clean URW (no painted or composite wood) from loads containing different amounts of refuse. The resulting material is transported to Facility 2 for processing. To obtain a better understanding of the quality of the separated URW, approximately 100 cubic yards of the material was processed with a tub grinder by Facility 4 on four separate occasions. The workers were not aware that this material was to be processed in this manner and analyzed.

Table 22: Facility 4 URW Characterization Results (Manufacturing End Use)						
Analytical Parameter	**Units**	**Sample 1 2-3-97**	**Sample 2 2-5-97**	**Sample 3 2-7-97**	**Sample 4 2-10-97**	**Average (Std. Dev.)**
Chemical & Physical Characteristics						
Total solids	%	83.6	79.4	82.4	84.1	82.4 (2.1)
Volatile solids	%	99.0	98.7	99.2	99.1	99.0 (0.2)
Bulk density	Lb/cy	334	314	327	322	324 (8.2
Brightness	Rating	2	2	2	2	2.0 (0)
Arsenic	Mg/kg	Nd	2.8	1.8	nd	1.2 (1.4)
Cadmium	Mg/kg	0.12	0.12	0.12	0.11	0.12 (0.01)
Chromium	Mg/kg	1.7	3.3	2.7	1.2	2.2 (0.9)
Copper	Mg/kg	2.6	4.1	2.7	1.7	2.8 (1.0)
Lead	Mg/kg	3.3	4.9	1.8	1.5	2.9 (1.6)
Nickel	Mg/kg	0.9	1.0	0.6	1.9	1.1 (0.6)
Zinc	Mg/kg	18.9	45.3	14.1	24.7	25.6 (13.7)
Sieve Analysis (% passing sieve)						
< 3 inch (76.2 mm)	%	89.8	90.8	92.1	87.0	89.9
1 inch (25.4 mm)	%	72.1	71.4	72.4	64.6	70.1
5/8 inch (15.9 mm)	%	57.5	52.8	57.1	49.4	54.2
3/8 inch (9.5 mm)	%	38.5	32.2	35.8	28.5	33.7
5/16 inch (7.9 mm)	%	31.1	25.3	28.9	21.7	26.8
3/16 inch (4.75 mm)	%	18.8	13.0	14.8	10.5	14.3
1/25 inch (1.0 mm)	%	4.3	2.6	2.1	1.4	2.6
Inert Contaminant Content						
Rocks	%	0.50	0.23	0.02	0.03	0.20
Sand and dirt	%	Nd	0.3	nd	nd	
Ferrous metal	%	Nf	nf	nf	nf	nf
Non-ferrous metal	%	Nf	nf	nf	nf	< 0.01
Total composite	%	3.44	2.32	1.88	3.59	2.81 (0.84)
Plywood	%	3.40	2.30	1.88	3.59	2.79 (0.83)
Particleboard	%	0.04	0.03	nf	nf	0.02 (0.02)
Oriented strand brd.	%	Nf	nf	nf	nf	nf
Plastics	%	0.02	0.01	0.03	0.01	0.02 (0.01)
Total painted wood	%	0.06	0.07	nf	0.03	0.04 (0.03)
Pre-consumer paint	%	0.06	0.07	nf	0.01	0.03 (0.03)
Post-consumer paint	%	Nf	nf	nf	0.03	0.01 (0.01)
Treated wood	%	Nf	nf	nf	nf	nf
Paper/cardboard	%	0.16	< 0.01	0.08	2.16	0.61 (1.05)
Roofing material	%	Nf	nf	nf	nf	nf
Foam rubber	%	Nf	nf	nf	nf	nf
Styrofoam	%	Nf	nf	nf	nf	nf

Total solids = 100 - moisture content
Total composite = plywood + particle board + oriented strand board
nd – Analyte was not detected
nf – Specific contaminant type was not found
Total painted wood = pre-consumer paint + post-consumer paint

This product has a high total solids and volatile solids content. The high volatile and total solids content is an apparent result of the positive sort picking line, where only clean wood is manually removed for processing. The positive sort picking line segregates dust, grit, and wet materials from the final product. The trace metal levels are low, indicating painted wood and other refuse that might contain trace metals were excluded through the positive sort picking line.

Sieve analysis results indicate an excessively high overs and unders content for use as a manufacturing feedstock. However, the particle size is adequate for use as a biomass fuel. Approximately 10% of the product was greater than three inches and approximately 14% was less than 3/16 inch. These results were expected since the material was processed in a tub grinder and not screened afterwards. In addition, an abundance of large-sized pieces were produced and discharged when the tub grinder was near empty, however, continuous input of material in a full-scale operation would alleviate this problem.

This product contained a small concentration of contaminants. It did not contain any ferrous metal, non-ferrous metal, oriented strand board, treated wood, roofing material, foam rubber, or styrofoam. The small amount of rocks that were found resulted from this material being ground on a dirt surface.

5.0 END USER TECHNICAL DISCUSSIONS

5.1 INTRODUCTION

Meetings with composite wood and pulp and paper manufacturing personnel were conducted to obtain a better understanding of usability constraints of urban recycled wood (URW) in these manufacturing processes. The meetings provided an opportunity to introduce the results of the project and to encourage use of URW. The composite wood manufacturing meeting, held on April 23, 1997, in Portland, Oregon, was attended by six individuals who represented three firms engaged in composite wood manufacturing and a consulting firm to this industry. Personnel involved in the sourcing and purchase of feedstock and the manufacturing process were also present. In addition, a URW processor attended this meeting.

The pulp and paper manufacturing meeting, held on April 28, 1997, in Seattle, Washington, was attended by individuals representing each of the five pulp and paper manufacturing firms. Two of the attendees were involved in feedstock procurement and the other three attendees were involved in the manufacturing process. The URW processor that attended the composite wood manufacturing meeting also attended this meeting.

5.2 URBAN RECYCLED WOOD CONTAMINANT CONTENT AND QUALITY

The primary issue of both end user technical discussions was the importance of processed URW quality (i.e., contaminant content, particle size and consistent quality) and the effect of this feedstock on the manufacturing process and quality of the manufactured product. The consensus of the attendees was that contamination in URW was a constraint to its use. Contaminants such as plastic, sand and grit, metals, and other inert materials can have a significant effect on the manufacturing process and product quality.

The attendees also acknowledged that the contaminant issue was significant several years ago when URW was first introduced in composite wood and pulp and paper manufacturing processes. This was due to both the URW processors and the end users initially learning how to make and use URW. Since that start-up period, the remaining URW processors have developed more sophisticated techniques for sourcing clean materials and removing contaminants. Likewise, manufacturers who are currently using URW have learned how to better use it as a manufacturing feedstock. For example, some manufacturers have added additional magnets for metals removal. Currently, URW being produced as a manufacturing feedstock has a low contaminant level and the few manufacturers using URW appear to be satisfied with the quality of the product.

How the different contaminants affect the manufacturing process and/or product quality is important for processing, and using the processed URW as a manufacturing feedstock. This was a focal point of discussion during the meetings. The following section will discuss how specific contaminants affect the manufacturing process, product function, and product aesthetics.

Effect of Specific Contaminants on Manufacturing Process

The use of URW, especially those containing rocks, sand, grit, and metals, requires additional process supervision and the purchase of auxiliary equipment for cleaning. As noted in Table 20, the presence of some contaminants can have a significant effect on the manufacturing process. In particular, rocks, sand and grit, and metals can cause excessive equipment wear and even equipment breakage. One papermill employee indicated that the use of URW requires monthly replacement of refiner plates as opposed to replacement every three months when virgin feedstocks are used.

Table 23: Effect of Specific Contaminants on the Manufacturing Process

Contaminant	Effect on Process
Rocks Sand and grit Metals	• ***Biomass fuel:*** rocks can explode causing damage to the boiler; these materials also tend to blind the internal grate requiring more frequent cleaning. • ***Dry composite wood manufacturing***: materials can cause sparks leading to fires or explosions. • ***Composite wood and paper manufacturing:*** materials cause excessive equipment wear and potential breakage, especially refiner plates.
Plywood Particle board Oriented strand board Laminates Painted wood	• ***Biomass fuel***: high levels of painted wood can elevate trace metals content of ash. • ***Composite wood manufacturing***: no effect on process if present in low concentrations. • ***Paper manufacturing***: water insoluble glues from composite wood can harden, become tacky, and "gum" up equipment.
Plastics Styrofoam Rubber	• ***Biomass fuel***: no effect on process; however, excessive amounts of these contaminants, especially plastics, may violate operating permit • ***Composite wood manufacturing***: plastics can wrap on pulleys and clog screens • ***Paper manufacturing***: plastics, styrofoam, and rubber can harden, become tacky, and "gum-up" equipment.

Effect of Specific Contaminants on Product Function

The incorporation of contaminants into the manufactured product can have a negative effect on product performance and function. The effects (Table 21) can cause decreased strength of composite wood products, incorporate excessive fines, and create unwritable areas on paper products resulting from plastic contaminants. Potential hazards and consequent product liability can result from contaminants being incorporated into the finished product. As an example, rocks and metal incorporated into composite wood products can cause bodily injury if the contaminant is struck with a power tool. At the very least, these contaminants will increase the wear of finishing equipment such as saw blades and drill bits.

Table 24: Effect of Specific Contaminants on Product Function

Contaminant	Effect on Product Function
Rocks Sand and grit Metals	• ***Composite wood manufacturing***: in wet process these materials typically sink, however, incorporation of these materials through dry process can cause harm and injury through cutting, routing, drilling, etc. These contaminants also cause excessive equipment wear. Presence of metals in circuit boards can cause short circuiting. • ***Paper manufacturing***: these materials are typically not incorporated to the product.
Plywood Particle board Oriented strand board Laminates Painted wood	• ***Composite wood manufacturing***: excessive concentration of composite wood increases fines fraction, which reduces product strength; lead-based paints are a potential liability. • ***Paper manufacturing***: lead-based paints are a potential liability.
Plastics Styrofoam Rubber	• ***Composite wood manufacturing***: minimal effect on product function • ***Paper manufacturing***: plastics can stick on rollers, which can cause unwritable blemishes or holes on all paper passing over rollers.

Effect of Specific Contaminants on Product Aesthetics

Contaminants present in URW can have a significant effect on the aesthetics of the finished product (Table 22). Firms participating in the end user technical discussions (that have used URW as a manufacturing feedstock) have had to recall products that were negatively affected by contaminants in URW. Plastics seem to be the primary culprit, as the presence of only a small concentration can have a significant impact on product appearance.

Table 25: Effect of Specific Contaminants on Product Aesthetics	
Contaminant	**Effect on Product Aesthetics**
Rocks Sand and grit Metals	• ***Composite wood manufacturing***: can cause product blemishes; however, in wet process these materials sink and fall out of the product during formation; in dry process these materials tend to end up in core of product. • ***Paper manufacturing***: can affect feedstock brightness and paper quality.
Plywood Particle board Oriented strand board Laminates Painted wood	• ***Composite wood manufacturing***: lower density of painted wood can cause this material to end up on product surface to negatively affect the appearance of finish treatments. • ***Paper manufacturing***: water-based painted wood in small quantities is not a problem. At greater levels, water-based paints can discolor water to affect paper brightness; oil-based paints are more of a problem and end up as pulp dirt in the fiber.
Plastics Styrofoam Rubber	• ***Composite wood manufacturing***: lower density causes these materials to end up on product surface and negatively affect the appearance of finish treatments. Larger pieces can leave voids when cut, routered or mitered. • ***Paper manufacturing***: can directly end up on product surface or can cause marks or holes on large volumes of paper when caught on a paper roller, effects differ depending on type of plastic.

Development of Acceptable Contaminant Levels

Meeting results indicate that the amount of acceptable contamination is not necessarily based on technical issues, but is more a factor of economics. Contaminants present in URW can cause additional cost through equipment wear and breakage, inferior product quality, and product recall. Consequently, if the price of virgin feedstock is competitive with URW, manufacturers will require a high quality URW with an absolute minimum contaminant content. Alternatively, if the cost of virgin feedstocks is high, the additional cost of using URW may be offset.

Quality control of incoming loads is another factor that affects the acceptable contaminant levels. Given the large quantity of feedstock used by the composite wood and pulp and paper manufacturing industries, inspection and quality control of incoming feedstocks is extremely difficult. Only a small percentage of the incoming feedstocks can be inspected. Consequently, finding even the smallest quantity of a contaminant can result in the rejection of the incoming material.

5.3 HANDLING AND PROCESSING ISSUES

The handling and processing of URW is another constraint to using this material as a manufacturing feedstock. Many of the manufacturers indicated that URW, which has a different character, shape, and particle size distribution than virgin feedstocks, is difficult to handle and does not convey well through the existing systems. Composite wood and paper manufacturing facilities were designed to handle a wood chip-type material, which tends to be uniform in size and shape. In contrast, processed URW tends to be comprised of various-sized rectangular pieces that are at a much higher length-to-width ratio. The URW also tends to have very coarse and stringy edges, which promote clinging when handled. As a result, URW tends to bridge and hang-up on conveyor systems, which requires time and labor to correct.

The varied particle size distribution of URW also creates challenges during the actual process. As a composite wood feedstock, a large unders fraction can affect product strength. In the paper making process, smaller pieces tend to cook too fast during digestion, while larger particles cook too slow. Consequently, fiber from the larger and smaller pieces is lost during the digestion process. Overall, fiber yield is reduced in both cases.

5.4 ECONOMICS

There are considerable economic constraints when using URW as a manufacturing feedstock. In order for URW to be used extensively, the price differential between URW and virgin feedstocks must be large enough to account for the additional equipment wear, product down time, and general difficulties associated with processing this material.

For some manufacturing firms, a better understanding of the actual costs of additional equipment wear and other factors associated with the use of URW might allow for a more cost effective use of URW as a feedstock. At the time of this project (9/96 through 5/97), the market price for virgin feedstock was very low. During periods of low virgin feedstock prices, most mills cannot justify using URW given uncertainties associated with its use. However, the fiber feedstock market is highly volatile. When prices increase again, there will be a renewed interest in the use of URW as a manufacturing feedstock.

There is some market demand resulting from many recycled content products. This factor has made it economically worthwhile for the manufacturers to use recycled feedstocks; for URW, this has some bearing in the paper manufacturing industry. Procurement guidelines and regulations have increased requirements for recycled content paper, which has increased the use of recycled feedstocks in the paper manufacturing industry. However, URW competes directly with recycled paper (paper that has been recovered from the wastestream) and in general, recycled paper does not appear to have as many challenges to its use. Nonetheless, one manufacturer at the end user technical discussions indicated the recycled nature of URW is an important factor for using this feedstock for manufacturing paper that has a minimum post consumer fiber content.

In the composite wood manufacturing industry, URW content has essentially no value in the commodity markets (i.e. dimensional lumber sold to large retail markets). The meeting attendees indicated that their customers perceive the incorporation of URW in the product to be of no benefit and may actually be a potential detriment to product quality. However, a smaller composite wood manufacturing firm indicated that recycled content has some value in certain niche markets.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The project results indicate that many firms have had some experience using URW as a biomass fuel or manufacturing feedstock. The specifications and technical requirements for URW as a biomass fuel are less stringent than for manufacturing end uses. Consequently, this market has been the easiest to access and most URW is currently going to biomass fuel. Overall, the end users are satisfied with the quality and performance of the product.

The URW market for biomass fuel appears to be expanding and should provide a stable market in the future. However, to maintain a healthy market, processors need to work closely with end users to meet their requirements. Several of the biomass fuel survey respondents indicated that a URW processor providing a lower quality product than requested would be quickly replaced.

In contrast to the biomass fuel end use, specifications and technical requirements for URW as a manufacturing feedstock are more stringent. As a result, URW processors have had greater difficulty placing materials in this market. The difficulty in accessing this market is due to the learning curve the processors and manufacturers experienced several years ago. Unaware of the challenges and subsequent processing accommodations needed for URW, but interested in alternative feedstock sources when virgin prices rose, a number of manufacturers tried using this material. Many experienced processing difficulties and most returned to virgin fiber feedstock as prices returned to previous levels.

Processors that first used URW as a manufacturing feedstock and are still producing it for the manufacturing industry, have substantially improved their process. Consequently, as demonstrated in the characterization data in this report, they are producing clean, consistent product. Firms currently using URW as a feedstock have made modifications to their manufacturing process and have learned how to better use this material.

It is acknowledged that virgin chip prices, and the subsequent demand for URW as a supplementary or alternative manufacturing feedstock, will increase in the next few years. Both URW processors and forest industry product manufacturers should consider developing the tools, processes, and skills needed to utilize URW as a resource.