ROADS & TRANSPORTATION
Technical Note TN-289 June 1999

TN289

THE ECONOMICS OF OPERATING A SATELLITE LOG STORAGE YARD

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Abstract

In 1995–96, the Forest Engineering Research Institute of Canada (FERIC) undertook a case study of an established satellite log storage yard supporting the Daishowa-Marubeni International Ltd. pulp mill near Peace River, Alberta. The study looked at the total wood supply system for the pulp mill, and documented the incremental and total wood handling costs both without and with the use of the satellite log storage yard. The potential for additional log breakage due to extra handling in the satellite log storage yard was investigated, and other potential costs and benefits were identified. A computer spreadsheet was developed to facilitate the manipulation and analysis of data obtained from similar field studies.

Introduction

In 1994, Daishowa-Marubeni International Ltd. (DMI) initiated discussions with the Forest Engineering Research Institute of Canada (FERIC) and other interested parties, on the use of a satellite log storage yard to supplement the storage capacity at its pulp mill near Peace River, Alberta. DMI typically stored enough logs in the millyard during the winter haul season to sustain mill production through the summer and fall. However, in anticipation of a future mill production increase, DMI personnel became concerned about the storage capacity of the millyard and the logistics of handling increased truck traffic. Storing the mill's entire log inventory at the pulp mill would require an expansion of the existing millyard or a redesign of the entire log handling/storage system. Therefore, DMI proposed the use of a satellite log storage yard as an alternative. To study the concept, an arrangement was made with Manning Diversified Forest Products Ltd. (MDFP) to utilize a portion of its millyard near Manning, Alberta, to establish a satellite log storage yard. This satellite log storage yard was first used in the winter of 1994–95, when approximately 100 000 m^3 of tree-length aspen and poplar logs were inventoried.

In 1995–96, FERIC studied the wood supply system of the DMI pulp mill. FERIC determined the costs and benefits of using the satellite log storage yard, and developed a computer spreadsheet to aid in the analyses. Funding assistance for the study was provided by Alberta Economic Development.

Objectives

The primary objective of this project was to undertake a case study of the DMI operation, including:

- a detailed economic analysis of the pulp mill's log supply operation both without and with a satellite log storage yard
- an examination of the log breakage due to increased handling when using a satellite log storage yard
- an assessment of the benefits of using off-highway vehicles to deliver logs from the cutblocks to the satellite log storage yard in winter, and long log B-trains to transfer the logs from the satellite log storage yard to the pulp mill in summer

Keywords: Log storage yards, Satellite operations, Economic analysis, Breakage, Payload, Alberta

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The secondary objective was to develop a computer simulation program, based on the case study results, and to use it to undertake a cost/benefit analysis.

Site Description

The satellite log storage yard was established in an unused section of the MDFP millyard. This yard was adjacent to the main paved highway to Peace River, situated approximately 95 km to the south. It also had direct access to active cutblocks to the west, via a private, off-highway haul road. Wood from other cutblocks was delivered directly to the DMI millyard by highway-legal vehicles. See Figure 1 for a layout of the main study components.

Equipment Description

At the satellite log storage yard, there was one Komatsu PC300HD log loader with a butt'n'top grapple, owned and operated by Homestead Holdings Ltd. and contracted to DMI.

At the millyard, there were three Wagner model L4-130 rubber-tired stackers and two Caterpillar 330 butt'n'top loaders, all owned and operated by DMI.

Study Methods

A major problem within DMI's log supply operations, as identified by DMI personnel, was the congestion of log truck traffic both in the millyard and on the approach roads during the winter haul season. This resulted in long delays and considerable frustration for the drivers. Any increase in millyard log intake would be complicated by the lack of additional highway-legal trucking capacity in the area during this period. To address this problem, higher-capacity off-highway trucks were used to deliver a portion of the required log inventory to a satellite log storage yard. This was expected to reduce the number of trucks entering the millyard during the winter and hence reduce congestion and truck waiting time. However, with this arrangement, a summer log haul was necessary to move the logs from the satellite log storage yard to the mill. A B-train designed to carry long logs was considered to be the most efficient configuration for hauling highway-legal loads.

Economic Analysis

To evaluate the economic costs and benefits of utilizing a satellite log storage yard, FERIC compared the operation of the entire log supply system for the mill, without and with a satellite log storage yard, over

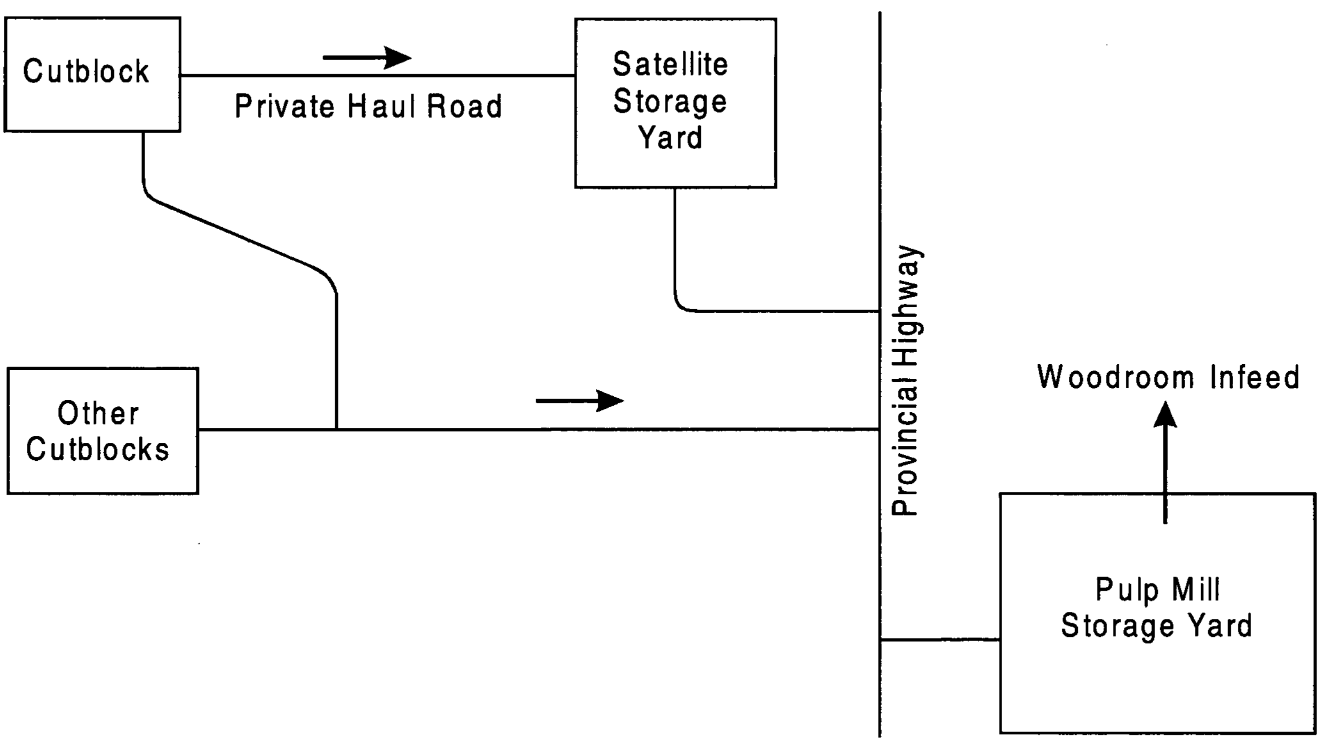

Figure 1. Log haul and storage schematic.

a one-year period. Areas of cost savings and increases were identified and quantified to determine the total annual log handling cost. Costs were calculated for each phase of the operation, starting with the loading of the trucks in the cutblocks, through to placing the bundles of logs on landings adjacent to the mill's woodroom infeed decks. Included were the costs incurred at the satellite log storage yard; unloading and reloading costs; transportation costs; and the costs of unloading, storing and retrieving bundles in the millyard.

The following operating parameters were assumed:

Without a satellite log storage yard. The total volume of logs required to support the mill's demand is 1.25 million m^3, and is transported by highway-legal vehicles (with winter weight allowances) directly to the mill during the winter haul period. A haul rate of $11.44/t, which is the rate paid for wood delivered directly to the mill from the same cutblocks that feed the satellite log storage yard, is applied to all wood delivered directly to the mill even if the wood comes from other areas. Also, a volume equivalent to that delivered to the satellite log storage yard is retrieved from the extremities of the millyard during summer operations.

With a satellite log storage yard. All loads delivered to the mill in summer from the satellite log storage yard are unloaded directly to the woodroom infeed landings. The balance of wood required to satisfy the mill's daily requirement is retrieved from mill storage decks.

Without or with a satellite log storage yard. During the winter haul period, the full daily mill requirements are off-loaded from incoming trucks. The balance of the incoming logs are unloaded to the mill storage decks.

A series of time and motion studies was conducted to identify the cost components involved in handling the logs from the cutblocks to the mill infeed. The studies focussed on the following procedures:

- off-highway log trucks delivering to the satellite log storage yard in winter and the logs being unloaded into storage decks
- highway-legal long log B-trains being loaded at the satellite log storage yard in summer, hauling to the pulp mill, and being unloaded at the woodroom infeed landings
- various configurations of highway-legal log trucks delivering to the pulp mill in winter, and being unloaded to the woodroom infeed landings and to storage decks
- millyard stackers unloading trucks in winter and delivering bundles to the woodroom infeed landings and to storage decks
- millyard stackers unloading B-trains in summer and delivering bundles to the woodroom infeed landings
- millyard stackers retrieving bundles from storage decks in summer and delivering them to the woodroom infeed landings

Actual cost data for loading trucks in the cutblocks, on- and off-highway hauling, and unloading and reloading at the satellite log storage yard were provided by DMI. DMI also provided the costs involved in establishing and maintaining the satellite log storage yard at MDFP.

The cost of owning and operating the DMI stackers was calculated using FERIC's standard methodology to be $119.03/h. This hourly cost permitted the comparison of costs of different tasks performed by the stackers in the millyard.

Log Breakage Analysis

Logs were loose-decked in the satellite log storage yard but were restrained in bundles by two wrapper cables for decking in the millyard. The logs were observed being fed onto the debarker infeed conveyors to determine if the extra handling of the logs from the satellite log storage yard produced more broken (i.e., short) pieces than the logs retrieved from storage in the millyard. The value of the logs themselves was not included in the economic analysis, since all but the smallest pieces (which became hog fuel) were used to produce chips for the pulp mill.

At the woodroom infeed, the operation of the butt'n'top loaders was observed as logs were moved from the landings onto the infeed conveyors. Since mill practice dictated that all logs enter the woodroom with butts forward, a high percentage of logs from the mixed orientation B-train bundles had to be turned end-for-end as they were transferred from landing to conveyor. Piece counts of three different samples of logs were also made as they were fed onto the infeed conveyors. The samples, each consisting of approximately the same number of bundles, were taken from three sources:

- logs delivered from the satellite log storage yard in summer

- logs retrieved from mill storage in summer
- logs delivered directly from the cutblocks in winter

The pieces were tallied based on three length categories: under 1.2 m, 1.2–3.7 m and over 3.7 m. This indicated whether the double handling of the logs in the satellite log storage yard had caused additional breakage (i.e., an increase in the number of short pieces), and therefore an increase in the overall number of pieces handled by the woodroom.

Debris from the two samples processed during the summer operations was collected and set aside in separate piles. FERIC researchers studied the contents of the two piles, again looking for evidence of increased breakage, i.e., a higher percentage of short pieces, from the bundles delivered from the satellite log storage yard.

Comparison of Vehicle Payloads

During the winter haul period, FERIC observed a variety of vehicle configurations. The 5-axle tandem truck/tandem pole trailer was predominant, but single and tandem jeeps, tandem and tridem semi-trailers, and 8-axle B-trains were also present. During the summer haul period, FERIC observed the 8-axle B-trains moving the logs from the satellite log storage yard to the mill. The 8-axle B-train configuration, modified to haul long logs, had not yet been approved by Alberta Transportation and Utilities. Therefore, the trucking contractor, Homestead Holdings Ltd., with support from DMI, obtained operating permits for several units to be used and evaluated on the haul from the satellite log storage yard at MDFP to the DMI millyard.

Computer Simulation Program

A generic computer program was developed and used to process some of the data collected. Results were then compared to those obtained by manual calculation and a judgement was made as to the suitability of the program for use by others. Subsequently, a spreadsheet was created using Microsoft Excel®. This program facilitated the manipulation of the raw data, including a sensitivity analysis of the cost study results to the variability of the weight/volume conversion factor.

Results and Discussion

Economic Analysis

The data provided by DMI reflect operations from November 1, 1995 to October 31, 1996. This information is presented in the first section of Appendix I.

Costs of Developing and Operating the Satellite Log Storage Yard. In this study, DMI and MDFP integrated their harvesting operations in certain cutblocks to maximize efficiencies. Road costs were a shared responsibility. While MDFP was interested in the softwood, DMI wanted the hardwood, so the logging crews were able to harvest the cutblocks in a single-pass operation. The stems were sorted by species at roadside, and except for the occasional mixed-species cleanup load, all full truckloads delivered to the MDFP yard were either aspen/poplar for the DMI satellite storage decks or conifer for the MDFP storage decks. The land required for the satellite storage facility was owned by MDFP and was surplus to its immediate requirements. As a result, DMI obtained the use of the property for a nominal sum.

DMI's actual costs for the satellite log storage yard for the period, excluding the cost of operating the log loader, consisted of land rental of $1, annual yard cleanup and debris disposal of $3529, and road maintenance in the satellite log storage yard of $6704, for a total of $9964. Although not applicable in this situation, the total cost of developing and operating a satellite storage yard would also include costs related to:

- engineering and surveying
- land clearing, grading and road building
- installing electric services and lighting
- providing and/or operating weigh scales
- providing fire protection
- maintaining roads, lighting, fire protection system, etc.
- providing protection from insect infestation
- providing a machine and operator to unload and reload logs
- scaling sample loads

Annual Wood Handling Costs Without and With a Satellite Log Storage Yard. The incremental and total annual wood handling costs for the pulp mill, without and with a satellite log storage yard, were calculated based on data collected during field trips to the Peace River and Manning sites and the data provided by DMI. Detailed calculations are presented in Appendix I. The major cost differences in the pulp mill's log supply system between operating without and with a satellite storage yard are summarized in Table 1.

Table 1. Comparison of Major Cost Differences Without and With a Satellite Storage Yard

Description	Cost ($) Without satellite yard	Cost ($) With satellite yard	Added or reduced cost to implement a satellite yard ($)
Load & haul wood from cutblock through satellite yard to mill	-	1 326 498	+1 326 498
Load & haul wood directly to mill in winter	15 423 075	14 629 773	-793 302
Unload trucks directly to mill infeed landing in winter	358 637	358 637	0
Unload balance of winter haul to mill storage[a]	410 609	378 292	-32 317
Unload trucks directly to mill infeed landing in summer	-	55 127	+55 127
Retrieve bundles from mill storage in summer	814 141	744 177	-69 964
Additional costs related to operation of the satellite yard	-	9 964	+9 964
Total	17 006 462	17 502 468	+496 006

[a] Annual volume to be stored without satellite yard is 816 932 m^3; with satellite yard is 752 636 m^3.

The cost savings resulting from storing less wood in the millyard are attributable to reduced loading and hauling costs to deliver the wood to the millyard during the winter haul, and reduced stacker costs to unload, store and retrieve this wood. The loading and hauling cost savings are $26.78/bundle or $0.67/$m^3$, while the stacker cost savings are $5.44/bundle or $0.14/$m^3$. In addition, for every bundle delivered from a truck directly to the mill infeed deck landing in summer, there are savings in stacker costs of $30.23/bundle or $0.84/$m^3$. As well, the summer log haul would provide opportunity for increased employment for truck drivers and mechanics, and greater equipment utilization for the owner. However, these savings are more than offset by the additional costs specific to the satellite log storage yard. The net additional cost resulting from the use of the satellite log storage yard, based on the mill requirement of 1.25 million m^3 of wood per annum, is $0.40/$m^3$ (a 2.9% increase). This is based on the total volume of logs stored in the satellite log storage yard being only 5% of the annual mill requirement. Unfortunately, any attempt to increase the cost savings by increasing the volume of wood stored in and delivered from the satellite log storage yard causes an increase in the total handling and hauling costs incurred in delivering the wood to the millyard, which accumulate at a faster rate than the savings.

Log Breakage Analysis

FERIC researchers observed the feeding of the debarker infeed conveyors with logs from bundles delivered from three sources. Of the two samples processed during the summer observation period, one consisted of bundles retrieved from the mill storage decks, while the second consisted of bundles unloaded directly from B-trains delivering from the satellite storage yard. The third sample consisted of bundles unloaded directly from various configurations of vehicles delivering from the harvesting sites in winter. The double handling of the logs in the satellite log storage yard was expected to cause increased breakage of the logs, which would show up as an increase in the number of short pieces to be loaded onto the debarker infeed conveyors. Therefore, for each sample, the total number of pieces handled was recorded, as well as the breakdown of these totals into three length categories: <1.2 m, 1.2–3.7 m and >3.7 m. Table 2 shows the piece length distribution by percent for the three samples.

This comparison appears to confirm the expectation that there would be more broken pieces among the B-train loads from the satellite log storage yard. There was a higher percentage of pieces in the two shorter length categories and a lower percentage in the longest category from this source, compared to the other sources. However, the true difference in the shorter length categories between bundles retrieved from storage and bundles from the satellite log storage yard is probably less than indicated. While conducting the piece count, FERIC researchers were unaware that pieces that broke from bundles as they were being retrieved from mill storage decks were being picked up by the front-end loader operator and taken directly to a remote waste pile. Therefore, they were not included in the piece counts at the debarker infeed conveyors or in the debris analysis. The figures for the sample processed during the winter indicate significantly less breakage. This is probably because these bundles were handled the least, being unloaded from the trucks directly to the woodroom infeed landings. Alternatively, that particular sample of logs may have had less heart rot than the other samples (there appeared to be a high percentage of heart rot in the logs stored in the satellite log storage yard).

FERIC observed that numerous short pieces under 1.0 m in length dropped into the waste system through openings in the woodroom infeed deck before being handled by the operator. In addition, other short pieces made it onto the debarker infeed conveyors but were too short to span the gap between conveyor rolls at the cut-off saw, and these too dropped into the waste system. All of the material in the waste system was processed through a hog mill to produce hog fuel.

Despite the increased volume of short pieces, there was no noticeable decline in the ability of the operators to keep an adequate supply of wood flowing to the debarkers. Problems in the conveying system downstream from the infeed decks and in the waste system, rather than a lack of wood, were more often the cause of production delays. The woodroom was only operating at approximately 80% of required capacity during the periods of FERIC's observations. Most of the time, only one of the two woodroom infeed streams was in operation. At peak production rates, the issue of having to handle more pieces might become a more significant factor.

During the summer observation period, after the samples from the mill storage and satellite log storage yard were processed, the debris that had accumulated below the infeed landing was collected and deposited in separate piles. The FERIC crew then dug through each pile and recorded the length and average diameter of pieces 1.2 m and greater in length. Table 3 summarizes the results of this process.

The data presented in Table 3 indicate a trend opposite to that in Table 2. Table 3 shows a higher percentage of broken pieces (chippable debris) originating with bundles retrieved from mill storage, whereas Table 2 indicates a greater percentage of broken pieces (<3.7 m) in bundles delivered from the satellite log storage yard. As mentioned previously, some pieces broken during retrieval of bundles from mill storage never reached the woodroom infeed decks. Therefore, the data representing the percentage of short pieces (i.e., <3.7 m) from this bundle source are unrealistically low.

Another explanation is possible for the lower quantity of chippable debris and the higher percentage of short pieces originating with the bundles from the satellite log storage yard. These bundles are assembled with the short pieces in the middle to avoid losses in transport, and are handled less at the mill before being placed on the landing at the woodroom infeed deck. As a result, fewer pieces are dropped in front of the infeed deck landing and more short pieces are actually delivered to the debarker infeed conveyors.

Comparison of Vehicle Payloads

A sample of 42 trucks operating on the off-highway winter haul to the satellite log storage yard showed

Table 2. Piece Length Distribution by Percent

Source of bundles	Bundles (no.)	Percentage of sample (%)		
		<1.2 m	1.2–3.7 m	>3.7 m
Summer loads from mill storage	30	3	8	89
Summer B-train loads from satellite yard	33	4	15	81
Winter conventional & B-train loads from cutblocks	36	2	8	90

Table 3. Quantity of Chippable Wood Recovered from Debris

Source of bundles	Bundles (no.)	Average bundle mass (t)	Total mass (t)	Chippable debris collected	
				(kg)	(%)
Mill storage	30	37.6	1127.7	1270	0.11
Satellite yard	33	41.1	1356.3	1260	0.09

an average payload of 47.32 t. Except for two heavy-duty, off-highway vehicles, this group consisted of typical highway vehicles, generally loaded to maximum volumetric capacity. Aspen/poplar logs were rough and crooked, resulting in loads that were less dense than comparable loads of conifer logs. A sample of 145 vehicles loaded to highway-legal winter weight limits, hauling directly to the DMI mill, had an average payload of 40.47 t. Thus the off-highway vehicles provided a 17% payload advantage.

Based on the entire summer haul of 1458 loads, the average payload of the 8-axle B-trains moving logs from the satellite log storage yard to the mill was 41.10 t. If this wood had been transported by 5-axle truck/pole trailer units, with a summer highway-legal payload of approximately 25 t (39 600 kg gross combination weight or GCW, minus 14 600 kg tare), 2397 trips would have been required. Even if a tandem tractor/tandem jeep/tandem pole trailer configuration was used, the maximum payload attainable with legal axle loads would not have matched that possible with the 8-axle B-train.

To take full advantage of the payload potential of the B-train configuration, the load should have a mixed orientation of butts and tops to optimize weight distribution. However, this causes extra work for the butt'n'top loader operators, who are required to turn a large number of logs end-for-end when transferring them from the woodroom infeed deck landings to the infeed conveyors. This extra work could limit the throughput of the woodroom, and the extra rotating of the butt'n'top head could result in increased wear of the rotating components as well as higher maintenance costs. While no quantitative analysis was undertaken to investigate these possibilities, general observations indicated that the loader operators had no problem keeping ahead of the infeed conveyor operators at the time that FERIC conducted its field work. Also, rotating the load is one of the advertised features of the butt'n'top loaders, so excessive wear on these machines should not be expected for this type of operation.

Computer Simulation Program

The original concept of a computer model that could be used as a decision-making tool for comparing the costs and benefits of operating a satellite log storage yard did not prove to be workable. While the generic program that was developed produced some useful results, it was cumbersome and inefficient in arriving at a decision. As an alternative, an Excel® spreadsheet was created, using the equations developed in Appendix I and the field data collected on site, to determine annual wood handling costs with and without a satellite storage yard. Based on an annual volume requirement of 1.25 million m^3 and a weight-to-volume conversion factor of 0.939 t/m^3 (provided by DMI), there was a $0.40/$m^3$ (2.9%) net benefit resulting from operating without a satellite storage yard. A sensitivity analysis was conducted to determine the effect of variability in the weight conversion factor on the overall cost spread between the two scenarios. Differences were determined through a range of conversion factors from 0.93 to 0.98 t/m^3 and resulting costs differed over a range from $0.40 to $0.37/$m^3$, respectively. This 0.2% spread in cost differential is of low significance.

Other Scenarios

Financing the Log Inventory

Another potential cost saving, inherent in employing one or more satellite log storage yards, is the reduction in borrowing required to finance the log inventory. If a satellite log storage yard is located within reach of off-highway hauling trucks, the cost per tonne stored can be significantly less than for an equivalent volume delivered by highway-legal trucks and stored in the millyard.

Assume an operation with basic operating parameters similar to the DMI mill, with the volume required to support the mill operation between the end of one winter haul and the beginning of the next equal to 817 000 m^3. This volume has to be stored in one of three ways:

- in the millyard
- in one or more satellite yard(s)
- divided between the millyard and satellite storage yard(s)

If a minimum of 60 days operating inventory is stored in the millyard, then 587 000 m^3 would have to be stored in the satellite yard(s).[1] (See Appendix II for calculation of numbers used in this example.) Assume the value of inventory stored in the millyard is $23.70/t and the value of inventory in the satellite storage yard is $19.30/t. The difference of $4.40/t multiplied by the weight/volume conversion factor of 0.939 t/m^3 would result in a difference in valuation, based on volume, of $4.13/$m^3$.

In other words, for every 100 000 m^3 of wood stored in the satellite log storage yard, the accounting book value of the inventory would be $413 000 lower than if the same volume was stored in the millyard.

Therefore, if 587 000 m^3 were stored in the satellite log storage yard, the capital available to the company for other purposes would be $2 424 310 (i.e., 587 000 m^3 x $4.13/$m^3$).

However, if this inventory was stored in the millyard and the company required the same amount of capital, the extra cost (assuming 7% interest per annum and average storage time of 4.5 months) would be $62 766.

Increasing the Capacity of the Existing Millyard

To increase the capacity of the existing millyard instead of developing a satellite log storage yard, there are at least two possible approaches. The area of the existing yard could be expanded and the same methods could be utilized for handling, storing and retrieving the log bundles. The second approach would be to install a travelling overhead crane and implement a storage and retrieval system compatible with this equipment. Neither of these options was investigated in detail in this study. However, the following list itemizes some of the major cost considerations associated with expanding millyard storage capactiy:

- additional land
- engineering and surveying
- land clearing, grading, drainage system and surface preparation
- extension of electrical services and lighting
- extension of fire protection services
- crane and installation
- scaling additional sample loads
- additional annual maintenance and debris clean-up
- possible additional stacker requirement due to longer retrieval distances

The recent experience of Tolko Industries Ltd. at High Prairie, Alberta and Ainsworth Lumber Company Ltd. at Grande Prairie, Alberta has indicated that the cost of preparing a mill log storage yard suitable for mobile equipment is in the range of $40 000 to $100 000/ha, excluding the cost of the land. Storage capacity for such a yard is approximately 13 000 to 15 000 m^3/ha, and annual operating cost including salaries, equipment, maintenance and annual cleanup is estimated to be $4.88 to $5.50/$m^3$ of annual throughput (i.e., mill consumption).

Other Considerations

Using off-highway trucks to deliver the logs from the cutblocks to the satellite log storage yard provided a payload advantage compared to the average payload of a variety of highway-legal trucks. This would mean fewer trucks using the bush roads and fewer trips to haul the wood from the harvesting site. However, this advantage is not sufficient to offset the added costs associated with unloading and reloading at the satellite log storage yard.

Several other factors may affect the decision of whether or not to utilize a satellite log storage yard:

- As in the case study situation, by integrating the harvesting plans of DMI (a hardwood user) and MDFP (a softwood user) overall costs could be reduced by harvesting all species in a single-pass operation.
- The numbers do not reflect the effects of truck congestion and delays in the millyard, which were anecdotally reported as having been a frequent occurrence in the winter of 1995–96. Mill operating costs are not directly affected by these problems, since hauling costs are governed by contracts based on the weight of logs delivered and the time required to haul the wood. Excessive delays do, however, impact the productivity of hauling contractors who will ask to be compensated for excessive waiting times for unloading.

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[1] For comparison, DMI stored approximately 100 000 m^3 at the MDFP satellite log storage yard in 1994-95 and only 64 294 m^3 in the 1995-96 season.

- At the time of this study, the local truck population was almost 100% utilized, allowing little opportunity for expansion of the on-highway haul fleet. By utilizing off-highway trucks to deliver inventory to an accessible satellite storage yard, the number of trucks required for the on-highway winter haul to the millyard would be reduced, thus avoiding the availability problem and resulting in less congestion.

- The introduction of a summer log haul provides opportunity for increased employment for drivers and mechanics. For the vehicle owner, this could mean reduced employee turnover in addition to greater equipment utilization, and hence a reduction in fixed costs per unit of wood moved.

- For the summer on-highway haul, the long log B-train provides a payload advantage over other configurations that would minimize the number of loads required to move the inventory from the satellite log storage yard to the mill.

Conclusions

In this study, the total annual wood handling cost when using a satellite log storage yard was $0.40 m³ (or 2.9%) greater than when one was not used. This cost would be significantly greater if the mill operator had to bear the full cost of establishing and operating the satellite log storage yard. Also, while the value of the logs has little bearing on the cost comparison for a pulp mill operation, this would not be true in the case of a sawmill operation. Log breakage could have a significant effect on the value of pieces delivered to a sawmill and, hence, on the profitability of the operation. Although the costs are determined using highly variable conversion factors to convert volume to weight, a sensitivity analysis showed the effect on overall cost to be relatively insignificant.

Using off-highway trucks to deliver the logs from the cutblocks to the satellite log storage yard provided a 17% average payload advantage compared to the average payload of a variety of highway-legal trucks. However, this advantage is not sufficient to offset the added costs associated with unloading and reloading at the satellite log storage yard. During the summer log haul, the use of long log B-trains provided a distinct payload advantage over other available vehicle configurations, thus minimizing this cost component.

The analysis of the piece count data did not provide conclusive evidence to support the presumption that there is extra log breakage due to double handling in the satellite log storage yard. FERIC was unable to account for the number of pieces broken and lost during retrieval of bundles from mill storage decks. A more complete count might have indicated a negligible difference in breakage between loads delivered from the satellite log storage yard and loads retrieved from mill storage. Although there was definitely breakage of logs during unloading and reloading at the satellite log storage yard, there was little actual loss of wood. The short pieces were loaded into the centre of the loads on the B-train trailers to avoid loss in transit, and this reduced the possibility of dropping them in the millyard when the trucks were unloaded by the stackers.

In the overall financial picture of the mill, the lower unit value of log inventory in a satellite log storage yard as compared to the value in the millyard may be of importance. Capital not tied up in inventory could be made available for use in other projects benefiting the mill's bottom line.

A final conclusion as to whether the use of the satellite storage yard makes sense for DMI would involve the weighting of several competing considerations, with overall log handling costs being a key factor, but perhaps not the deciding one.

A computer spreadsheet was developed as a useful method of listing and manipulating the data, and arriving at a comparison of costs involving the two log supply system scenarios. Upon request, FERIC could use this program to assist other operators with similar analyses.

Recommendations

- When undertaking a cost analysis such as presented in this case study, the reasons for establishing a satellite log storage yard and the expected benefits, both operational and financial, should be clearly defined at the outset. This will provide the benchmarks against which the advantages and disadvantages of the proposed satellite operation can be judged.

- The long log B-train configuration does not have general approval for highway operation in any jurisdiction. At the time of the study, only the seven vehicles in the Homestead Holdings Ltd. fleet had permits to operate in Alberta for evaluation purposes. Therefore, a program should be established to pursue the computer modelling required in support of the regulatory process so that the long log B-train configuration evaluation can be completed.

Acknowledgments

The author would like to acknowledge the co-operation of the people at DMI, Peace River Pulp Division, who facilitated the gathering of raw data. The assistance of Darren Brownlie and Eivind Hestdalen in providing much of the statistical data on which this report was based is particularly noted. The assistance of Steve Blanton and others at MDFP eased the gathering of data at their location. Larry Giesbrecht of Homestead Holdings Ltd., who provided the long log B-train vehicles, was another enthusiastic supporter. FERIC employees who contributed to this study and report include Allan Bradley, Yvonne Chu, Shelley Corradini and several summer students. FERIC would also like to express appreciation for financial support provided by Alberta Economic Development, Forest Products Development Branch.

Disclaimer

Appendix I

Detailed Calculations & Derivations

Data

Number of days per year woodroom operated	329
Number of days per year winter log haul operated to the pulp mill	114
Number of days per year summer log haul operated from the satellite yard	48
Number of loads of logs (bundles) received at mill during winter haul	31 246
Total weight of logs received at mill during winter haul (t)	1 174 674
Average weight to volume conversion factor for this wood (t/m^3)	0.93918
Annual round wood consumption by woodroom (m^3)	1 250 000
Number of days per year winter log haul operated to the satellite yard	82
Number of loads of logs received at satellite yard during winter haul	1 447
Total weight of logs received at satellite yard during winter haul (t)	63 787
Number of loads received at the mill from satellite storage yard during the summer haul	1 458
Total weight of logs received at mill from satellite yard during summer haul (t)	59 923
Average weight to volume conversion factor for this wood (t/m^3)	0.93201
Cost of loading trucks in the cutblocks ($/t)	1.70
Cost of hauling from the cut blocks to the satellite yard ($/t)	6.11
Cost of unloading trucks in satellite yard ($/t)	1.50
Cost of reloading trucks in satellite yard ($/t)	1.50
Cost of hauling from satellite yard to mill ($/t)	10.71
Cost of hauling to the mill from same cut blocks that fed satellite yard ($/t)	11.44
Charge for use of unmanned mill scale during summer haul - one scale person, one day/week ($/day)	122.64

Assumptions

1. The total volume of logs to be moved to satisfy the annual mill requirement is 1 250 000 m^3.
2. The haul rate for all wood delivered directly to the mill is $11.44/t, whether the wood originated in the same cutblocks that fed the satellite storage yard or elsewhere.
3. When operating without the satellite yard, a volume equivalent to that which was actually stored in the satellite log storage yard is assumed to be retrieved from the extremities of the millyard during summer operations.

Calculation of Annual Wood Handling Cost Without a Satellite Storage Yard

Cost to load trucks at cutblock landings and haul to the mill
$= (\$1.70 + \$11.44)/\text{t} \times 1\,250\,000 \text{ m}^3 \times 0.939 \text{ t/m}^3$
$= \$15\,423\,075$

To calculate the number of highway-legal truck loads, or bundles, of logs to be hauled per year (i.e., per winter hauling season), the average bundle volume must be known. This can be derived from data provided by DMI for the winter haul as follows:

Average volume of bundles delivered to the mill in winter
$= (1\,174\,674 \text{ t}) \div (31\,246 \text{ bundles} \times 0.939 \text{ t/m}^3)$
$= 40.03 \text{ m}^3/\text{bundle}$

Total number of highway-legal truck loads, or bundles, to be hauled per year
$= 1\,250\,000 \text{ m}^3 \div 40.03 \text{ m}^3/\text{bundle}$
$= 31\,226.6$ bundles

Number of bundles/day required to satisfy the mill requirements
= 1 250 000 m^3/year ÷ (329 days/year × 40.03 m^3/bundle)
= 94.9 bundles/day

Number of bundles to be unloaded from trucks directly to the woodroom infeed deck landings during the winter log haul period
= (114 days) × (94.9 bundles/day)
= 10 818.6 bundles

Using FERIC's standard machine costing methodology, the cost of ownership and operation of the Wagner stackers in the millyard was calculated to be $119.03/h. From the time and motion study of the stackers, the average cycle time for a stacker to unload a truck and deliver the bundle to the woodroom infeed landings in winter is 16.71 min, resulting in a stacker cost per bundle
= ($119.03/h ÷ 60 min/h) × (16.71 min/bundle)
= $33.15/bundle

Total stacker cost for all bundles unloaded to woodroom infeed landings in winter is
= (10 818.6/bundle) × ($33.15/bundle)
= $358 637

Number of bundles to be stored
= total number bundles to be hauled to mill in winter number – of bundles unloaded to woodroom infeed landings in winter
= 31 226.6 – 10 818.6
= 20 408 bundles/year

The cost of stacker operation to unload these bundles and place them in storage is calculated as follows. Average cycle time for stacker to unload truck and place bundle in the storage deck as determined from time and motion study is 10.14 min.

Stacker cost per bundle to unload truck at deck and place bundle in storage
= ($119.03/h ÷ 60 min/h) × (10.14 min/bundle)
= $20.12/bundle
Therefore, total cost of unloading trucks to mill storage
= $20.12/bundle × 20 408 bundles/year
= $410 609/year

Considering the cost of retrieving bundles from storage, assume that a volume equal to that which was stored in the satellite log storage yard would be retrieved from the extremities of the yard and the balance of the annual requirement from an average distance.

To calculate the volume of logs stored in the satellite log storage yard, a conversion factor is needed to reflect the weight/m^3 for this wood. Since no sample scaling data were available, assumptions were made and calculations were done using the known weight and weight/volume conversion factor for logs received at the mill from the satellite log storage yard in the summer of 1996. By accounting for the volume of wood processed through the satellite log storage yard, a value for the conversion factor for wood delivered to the satellite yard in winter (C.F. Winter) was calculated as follows:

Volume of logs received at satellite log storage yard
= volume of logs received at millyard in summer + volume of wood & bark lost in satellite log storage yard
= (weight of logs received at satellite log storage yard – weight of snow/ice on loads) ÷ C.F. Winter

Therefore,
C.F. Winter = [Weight of logs received at satellite log storage yard – weight of snow/ice on loads] ÷ [volume of logs received at millyard in summer + volume of wood & bark lost in satellite log storage yard]
Equation (A)

Assumptions / Estimates

1. Wood loss in satellite log storage yard was minimal
   - majority of broken pieces were picked up by loader and placed in centre of B-train loads
   - if wood loss was 1% or 'V' m^3 then $V \div (64\,295 + V) = 0.01$

   where 64 295 m^3 is the volume of wood received at the mill from the satellite log storage yard, as derived by dividing the scale weight received, 59 923 t, by the conversion factor for wood delivered to the millyard in summer (C.F. Summer) of 0.932 t/ m^3, determined by scaling of sample loads.

Therefore, V

$= (0.01) \times (64\,295\ m^3 + V\ m^3)$

$= 649\ m^3$

Note: A sensitivity analysis showed that an increase of 0.5% in the assumed wood loss would result in a decrease in the C.F. Winter of 0.005 t/m^3, a decrease in the weight of logs to be delivered directly to the mill during the winter haul of 5928.5 t, and a decrease in the cost of loading and hauling this wood of $77 900 (approx. 0.5%).

2. Assume snow and ice accumulation on loads arriving on the scale at the satellite log storage yard was 500 kg/ load on the total of 1447 loads delivered.

Therefore,

= Total weight of snow/ice

$= (500\ kg/load \div 1000\ kg/t) \times 1447/loads$

= 724 t

Using Equation (A), C.F. Winter

$= (63\,787 - 724)\ t \div (64\,295 + 649)\ m^3$

$= 0.971\ t/m^3$

Note: This is for cutblocks supplying the satellite log storage yard.

Therefore, volume of logs stored in satellite log storage yard

$= [63\,787\ t\ (logs) - 724\ t\ (ice/snow)] \div 0.971\ t/m^3$

$= 64\,946\ m^3$

= volume to be retrieved from extremities of yard

Total annual volume to be retrieved

$= 1\,250\,000\ m^3 - (94.9\ bundles/day \times 40.03\ m^3/bundle \times 114\ days)$

$= 816\,932\ m^3$

Therefore, volume to be retrieved from average distance

$= 816\,932\ m^3 - 64\,946\ m^3$

$= 751\,986\ m^3$

An extreme distance of 0.9 km was established, being an average of the distances to decks at opposite ends of the millyard. The average distance used was 0.45 km. From the time and motion studies, the stacker cycle times for these two cases were 24.2 and 19.8 min, respectively, including the time required to place the bundle in a cradle, remove the wrapper cables and pick it up again. Hence, the stacker cost for retrieving a bundle from storage in each case would be $47.92 and $39.20.

Therefore the annual cost of retrieving a volume of logs, equivalent to that which could have gone to a satellite storage yard, from the extremities of the mill storage yard

$= (64\,946\ m^3 \div 40.03\ m^3/bundle) \times \$47.92/bundle$

= $77 747

Likewise, the annual cost of retrieving the balance of the mill requirement based on an average retrieval distance

$= (751\,986\ m^3 \div 40.03\ m^3/bundle) \times \$39.20/bundle$

= $736 394

Total annual retrieval cost
= $736 394 + $77 747
= $814 141

Summary of the total annual wood handling costs without the satellite storage yard:

Load and haul all wood to the mill	$15 423 075
Unload trucks at woodroom infeed in winter	358 637
Unload to mill storage, balance of annual mill intake	410 609
Retrieve bundles from extreme and average distances	814 141
Total	**$17 006 462**

or ÷ 1 250 000 m^3 = **$13.60/$m^3$**

Calculation of Annual Wood Handling Cost Utilizing a Satellite Storage Yard

Cost to load trucks at cutblock landings, haul to the satellite log storage yard and unload into storage decks
= ($1.70 + $6.11 + $1.50)/t × 63 787 t
= $593 857

Cost to load trucks in satellite log storage yard and haul to the mill
= ($1.50 + $10.71)/t × 59 923 t
= $731 660

Charges for use of unmanned scale at mill to weigh incoming loads from satellite log storage yard
= $122.64/week × (48 days ÷ 6 days/week)
= $981

An analysis of the time and motion study data collected showed that the average cycle time for a stacker to unload a truck and deliver the bundle to the woodroom infeed landing in the summer was 19.06 min. Using this figure, the cost per bundle to operate a stacker to unload a truck and deliver the bundle to the infeed landing in summer
= ($119.03/h ÷ 60 min/h) × (19.06 min/bundle)
= $37.81/bundle

Cost of operating the stackers to unload all loads received from the satellite log storage yard during the summer haul and deliver them to the infeed deck landing
= 1458 bundles × $37.81/bundle
= $55 127

To calculate the volume of wood required to be delivered directly to the mill in winter, the following equation can be used:

Required annual millyard intake
= volume received from satellite log storage yard (in summer) + volume delivered directly to mill (in winter)

Therefore, required volume to be delivered directly to mill (in winter)
= 1 250 000 m^3 – (59 923 t ÷ 0.932 t/m^3)
= 1 185 705 m^3

Convert this to weight using the conversion factor determined from scaling of loads received at the mill in winter:

Required weight of logs to be delivered directly to mill in winter
= 1 185 705 m^3 × 0.939 t/m^3
= 1 113 377 t

Cost of loading and hauling to the mill in winter (that portion of the annual wood supply not processed through the satellite log storage yard)
= ($1.70 + $11.44)/t × 1 113 377 t
= $14 629 773

Of the total volume of wood arriving at the millyard in winter, a portion will be fed directly to the woodroom infeed to meet the mill's daily requirements, and the balance will be unloaded to the mill storage decks. From previous calculations:

Number of bundles to be unloaded directly to the woodroom infeed deck landings in winter
= 10 818.6 bundles
Total stacker cost for all bundles unloaded to woodroom infeed landing in winter
= $358 637

The balance of the wood delivered to the mill in winter is unloaded to the storage decks. The number of bundles to be stored can be calculated as follows:
Number of bundles to be stored = (volume delivered directly to the mill ÷ volume/bundle)
– number of bundles unloaded to woodroom infeed landings during winter haul
= (1 185 705 m^3 ÷ 40.03 m^3/bundle) – 10 818.6 bundles
= 18 801.8 bundles

Stacker cost per bundle to unload truck at deck and place bundle in storage
= $20.12/bundle

Total cost of unloading trucks to mill storage decks
= 18 801.8/bundles × $20.12/bundle
= $378 292

The next component cost to calculate is the annual cost of retrieving bundles from storage. This requires determining the volume of wood to be retrieved in terms of number of bundles.

Annual volume to be retrieved (bundles) =
[{average daily woodroom requirement (bundles) – average no. of loads/day received from satellite log storage yard in summer} × no. hauling days in summer] + [average daily woodroom requirement × no. of non-hauling days in operating year]

Annual volume to be retrieved
= [{94.9 bundles – (1458 loads ÷ 48 days)} × 48 days] + [(94.9 bundles/day){329 days/year – (114 days/year + 48 days/year)}]
= 18 945.5 bundles/year

From time and motion study data, the average cycle time for a stacker to retrieve a bundle from an average distance of 0.45 km and deliver it to the infeed deck landings was 19.8 min.
Total annual cost of retrieving bundles from storage
= {($119.03/h ÷ 60 min/h) × 19.8 min/bundle} × 18 945.5 bundles/year
= $744 177/year

Summary of the total annual wood handling costs utilizing the satellite storage yard:

Move logs from cutblock landings to satellite log storage yard and unload to storage	$593 857
Reload and haul logs to mill	731 660
Use of scale at mill during summer haul	981
Stackers to unload summer trucks to infeed deck landing	55 127
Load and haul to mill in winter, balance of wood	14 629 773
Stackers to unload winter trucks to infeed deck landings	358 637
Stackers to unload balance of winter trucks to mill storage	378 292
Stackers to retrieve bundles from storage	744 177
Additional costs related to operation of satellite storage yard	9 964
Total	**$17 502 468**

or ÷ 1 250 000 m^3 = **$14.00/m^3**

Appendix II

Financing the Log Inventory - Detailed Calculations and Derivations

Another potential cost saving, inherent in employing one or more satellite log storage yards, is the reduction in borrowing required to finance the log inventory. Typically, the value added to the wood, from the point of loading the logs onto the trucks in the cutblocks to the unloading at the storage decks, is the sum of the incremental costs. If a satellite yard is located within reach of off-highway hauling trucks, the cost per tonne stored can be significantly less than for an equivalent volume delivered by highway-legal trucks and stored in the millyard.

Assume an operation with basic operating parameters similar to the DMI mill

- The mill operates 329 days/year and consumes 1 250 000 m^3 of logs.
- The winter log haul operates for 114 days during which time the mill consumes

(114 days/year ÷ 329 days/year) × 1 250 000 m^3 = 433 131 m^3 of logs which are delivered directly from the trucks to the mill infeed. Rounding this figure to 433 000 m^3, the balance of annual mill consumption is

(1 250 000 m^3 – 433 000 m^3) = 817 000 m^3

This volume has to be stored to support the mill operation during the period between the end of one winter haul season and the beginning of the next.

Assume a minimum inventory of 60 days' operating supply is stored in the mill storage yard as insurance against any unforeseen stoppage of the summer log haul from the satellite yard

= 60 days × 94.9 bundles/day × 40.03 m^3/bundle
= 227 931 m^3

Rounding this to 230 000 m^3, the volume to be stored in a satellite yard(s)
= 817 000 m^3 – 230 000 m^3
= 587 000 m^3

To evaluate the cost saving resulting from the use of a satellite yard, the following must be known:

- the length of time the logs are stored
- the cost of financing a dollar amount equivalent to the difference in valuation of the same volume of inventory stored at the two yards.

Theoretically, the first log stored in the satellite yard at the beginning of the winter haul season (e.g., November 15) could be the last one retrieved (e.g., on the following August 15). Allowing 30 days for mill shutdowns and 60 days to use the inventory stored in the mill log yard, the maximum storage time would be 9 months. Therefore, assume the average storage time is 4.5 months.

If the value of the inventory in the mill storage yard is	\$23.70/t
and the value of the inventory in the satellite storage yard is	\$19.30/t,
then the difference is	\$4.40/t

Using the weight/volume conversion factor of 0.939 t/m^3, the difference in valuation based on volume
= \$4.40/t × 0.939 t/m^3
= \$4.13/m^3

Therefore, if 587 000 m^3 of wood is stored in the satellite yard instead of in the millyard, the capital available to the company for other purposes would be

587 000 m^3 × \$4.13/m^3 = \$2 424 310

If, on the other hand, this amount of inventory was stored in the millyard, and the company required the same amount of capital, and had to borrow at 7% per annum, the extra cost would be:

(\$2 424 310 × 7%) ÷ (365 days/year × 4.5 months × 30 days/month) = \$62 766