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Two-staging to Super-skids with Bell Off-Highway Trucks

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Figure 1 - Bell truck carrying full tree length logs from a hauler pad

Abstract

Studies were carried out in three harvesting operations where six wheel-drive off-highway trucks fitted with pole trailers were two-staging full tree length material from the extraction site to a central processing site.

Gains in total system production are required to fully recover the extra cost of the trucks and to give a productivity improvement. These gains were achieved in the operations studied.

There are also indirect benefits such as improved safety and reduced soil disturbance achieved by the use of two-staging to the super-skids.

Production rates of the trucks varied with truck size, haul distance, and whether the trucks were working uphill or downhill loaded. Predicted production rates based on varying haul distances and slopes are presented.

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Introduction

The use of two-stage logging is an increasingly popular option in New Zealand forest harvesting. Bennett (1996) reported on seven two-staging operations that used a variety of machines (skidders, off-highway trucks and haulers) as the secondary extraction unit. Since that report there have been a number of other operations where two-staging has been used. In four of these, six wheel-drive Bell trucks fitted with pole and jinker trailers have been used. Overseas experience has shown that, in some circumstances, there are significant savings to be made by substituting off-highway transportation for conventional road construction (Stokes et al. 1992).

It is likely that there will be an increasing focus on the use of two-staging in the future with:

- more logging being carried out on steep sites where landing construction is expensive and landing areas are restricted in size
- increasing focus on optimising productivity of haulers and mechanised processors
- increasing awareness of safety issues associated with manual log processing near active haulers and loaders
- increasing volumes being harvested from woodlots; these often have relatively small areas to be harvested requiring potentially expensive roading, meaning the cost of roading as a proportion of total harvest cost is higher than for large plantations.

However, it is important to use the right machine, as harvesting system and machine balance are critical to obtaining even wood flows and avoiding bottlenecks (Falloon, 1995).

Two double-hauler operations and a mechanised ground-based operation were studied to determine production rates of Bell trucks used to transport tree-length material from an extraction landing to a processing landing.

Operation Descriptions

Operation 1 - consisted of two haulers (071 and 171 Madills) working at landings approximately 1100 m apart. The Madill 071 was 800 m and the Madill 171 was 350 m from the central processing landing. Each hauler had a 30 tonne excavator based at the landing for clearing the chute and loading the tree lengths on to a Bell B25 (25 tonne) six wheel-drive truck with a 2-axle pole trailer (Figure 1). The Bell B25 transported the tree lengths from the hauler landings to the log processing landing. The truck and trailer had drop stanchions fitted. The trucks were unloaded by releasing these and then pushing the tree lengths off with a rubber-tyred front-end loader (RTFEL). The stems were mechanically processed and the fleeting and loading of the logs was completed by the RTFEL and a 20 tonne excavator.

Operation 2 - consisted of a Timberjack feller-buncher (FB) (part-time) and a Timberjack/Waratah feller-delimber-buncher (FDB) (full-time). The FDB also delimbed the stems felled by the FB. A Komatsu D65 with an arch and a Timberjack 560 grapple skidder extracted the tree lengths to roadside. A 30 tonne excavator was used at roadside to load the tree lengths on to the truck. In this case, the loading point was approximately 1.35 km from the central processing landing. A Bell B30 six wheel-drive truck fitted with a pole trailer (similar to above) was used to transport the tree lengths to the central processing landing. Unloading the truck was also by drop stanchions and using the RTFEL. The tree lengths were mechanically processed into logs and the fleeting and loading were completed with an RTFEL and a 20 tonne excavator.

Operation 3 - consisted of two haulers (Bellis BE85 and BE70), working 2.1 and 3.35 km, respectively, from the processing landing. The tree length material was moved from the chutes and stockpiled by 30 tonne knuckleboom loaders. These loaders then loaded the tree length material on to a Bell B40B fitted with drop stanchions and a 2-axle pole trailer. The truck transported the tree lengths to the super-skid where the trees were unloaded by dropping the stanchions and pushing by loaders as in the other two operations. The wood was processed at the super skid by an excavator-based mechanised processor. Two loaders (1 RTFEL and 1 knuckleboom) fleeted the logs and loaded trucks.

Acknowledgments

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Methods

The Bell trucks were time studied for two days at each operation. Their load sizes were estimated by scaling sample logs and counting the number of logs in each load.

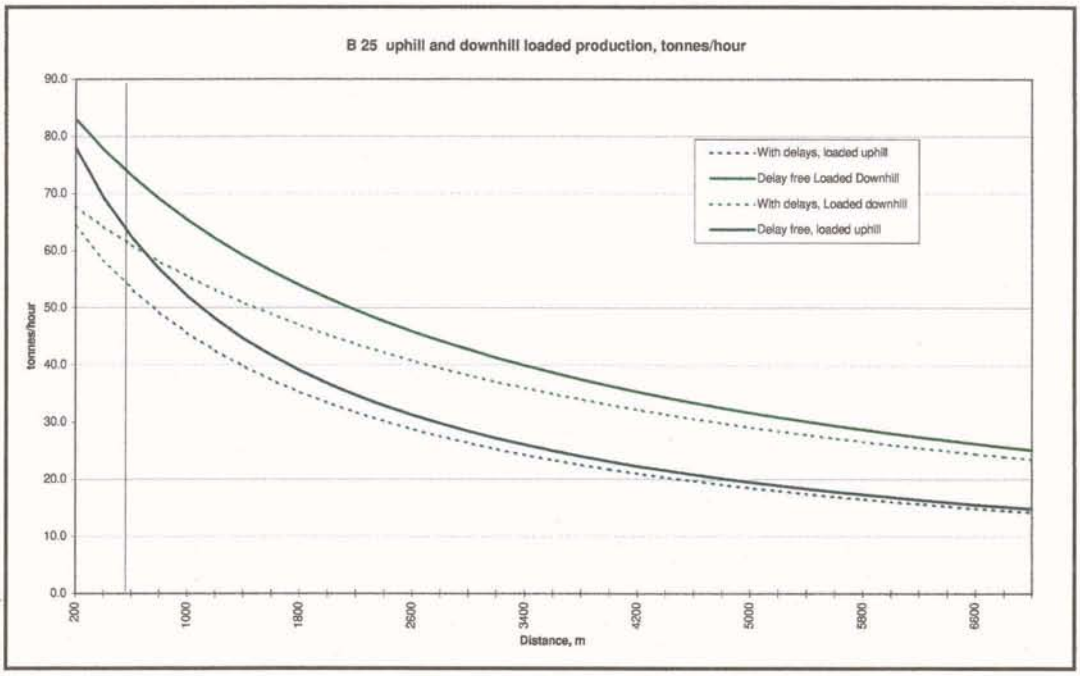

Figure 2 - Production including delays and potential delay-free production

The production from the extraction machines in Operations 1 and 2 was determined from daily records kept by the operators. Data were collected on the hours worked, delay times and the number of butt and top pieces extracted. In Operation 3 production data was obtained from long term records.

The hours worked by the machines at the processing site were also recorded. The production of the processors was not measured. However, they were processing all of the material presented to them. This meant that they had to work longer hours than the rest of the crews. The total hours worked were recorded.

Production (tonnes per hour) versus transport distance curves were derived from the study data.

Results

Operation 1 - *Cable logging system (2 haulers), mechanised processing*

The results of the time study analysis are shown in Figure 2, which shows potential delay-free production and estimated actual production.

The vertical line in the graph indicates the average haul distance (550 m) in this study.

In the longer haul (800 m), the truck was travelling loaded downhill (3^0 to 4^0 slopes) and in the shorter haul (350 m) the truck was travelling loaded uphill (3^0 to 5^0). The travel loaded speed varied considerably depending on whether the load was taken uphill (average 6 km per hour) or downhill (average 17 km per hour).

At the time of the study, the combined production of the two haulers in this setting was estimated at only 370 m^3 per day. The Bell B25 working from 7.00 am until 3.30 pm with no scheduled break, was able to keep up with this level of production. Average load size was approximately 30 tonnes. The average piece size was 1.46 m^3. An average load consisted of 19 tree lengths and nine broken pieces.

The processing operation was also able to keep up with the wood produced, but the processing machine worked a longer day (10 machine hours).

The average cycle time for the Bell B25 was 35 minutes, but this included 10 minutes of delays per cycle. The main delays were:

- waiting for the loader at the hauler pads (2.3 mins per cycle)
- waiting for the RTFEL to clear the unloading site (2.4 mins per cycle)
- waiting for the RTFEL to push off the load and lift the drop stanchions back into place (2.8 mins per cycle)

Long term production figures for this operation suggest that production levels of 500 m^3 per day were consistently achievable. This was 35% higher than the operation as it was observed and

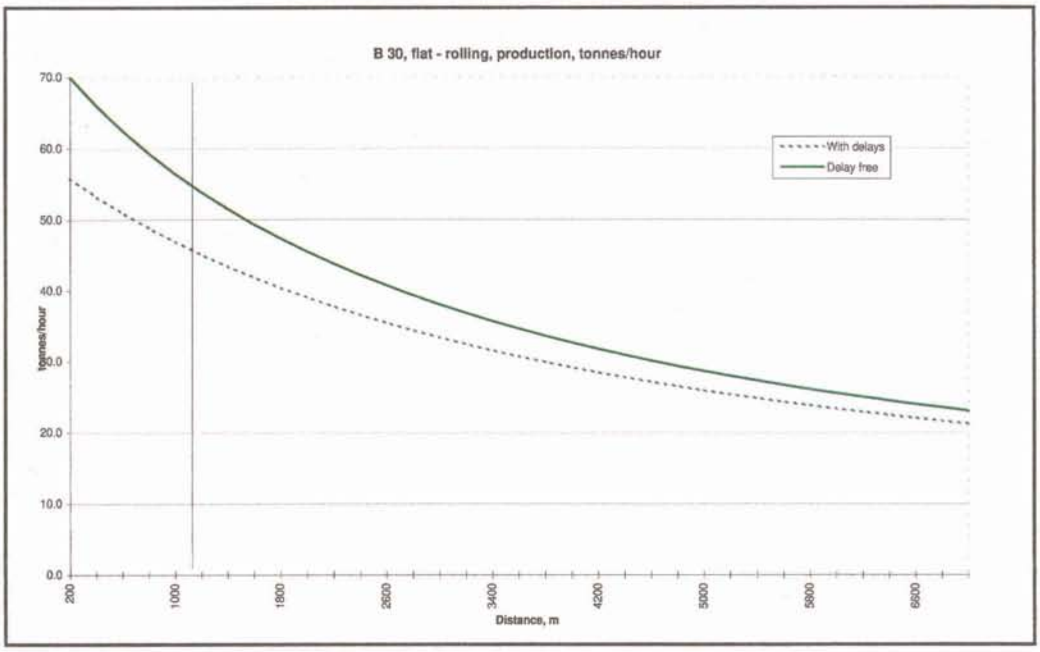

Figure 3 - Production rates and costs of Bell B30 with and without delays

also well over 30% higher than the combined production of the haulers when they were working separately. This gain in production was more than sufficient to cover the extra costs of the Bell truck. There are reductions in landing construction costs and subsequent gains in environmental performance (reduced sedimentation).

Operation 2 - *Mechanised ground-based system*

The Bell B30 was the subject of a two day time study, and production rates were derived. Figure 3 shows production with and without delays for the Bell B30.

The road at this site was undulating with slopes of 0^0 to 4^0. The transport distance averaged 1350 m. Average piece size was 1.45 m^3.

The Bell truck in this operation worked from 6.00 am until 3.30 pm with no scheduled breaks. This gave up to nine productive machine hours per day. Cycle times were 55 mins including delays. This could have been reduced to 45 minutes if the delay due to waiting for loaders was removed. The B30 was carrying full tree length loads averaging an estimated 37 tonnes. The Bell B30 was capable of 10 loads (370 tonnes) per day. The remainder of the 520 tonnes per day being produced by the crew was being transported on a second truck, which worked a part day.

This operation was set up specifically for the two-staging with the Bell truck, so a direct "before and after" comparison of production with and without the two-staging was not possible. However, comparative estimates indicate that the total logging cost is likely to have been lower with two-staging to the super skid with the Bell truck due to a higher volume throughput. The gain in production over a conventional mechanised crew based on the contractor's previous operation was in the order of 25%.

Another significant advantage is that for the site studied, year round operations were possible using the Bell truck. With conventional systems, this area was not logged in winter due to boggy soil conditions and difficulties getting logging trucks on and off landings.

Operation 3 - *(double hauler) and Bell B40, mechanised processing*

Two haulers were working 2.1 and 3.35 km from the super skid, just over one kilometre apart, with a 40 tonne Bell truck taking tree lengths to a central landing, with processing by a mechanised processor.

Prior to the introduction of the Bell truck, the haulers, working independently of each other, were producing between 200 and 230 tonnes per day (up to 460 tonnes per day total). The mechanised processor processed the wood from the first operation. In the second operation processing was done manually. With the move to two-staging, the total production had risen to around 700 tonnes per day, an increase of 50%. This increased production was possible as the haulers were focused solely on extracting wood and were not limited or interfered with by the processing landing. The gain in production more than covered the extra costs of the added machinery and provided an improvement in productivity.

In this operation, there were no anticipated savings from roading. The Bell B40 was carrying loads of up to 55 tonnes. The truck may have a gross weight of up to 80 tonnes. The aim is to operate year round in all weathers. Reasonable quality roads are therefore required for such a large truck in wet conditions. However, landing construction costs have been reduced by approximately 50%, due to the reduction in size of the hauler pads.

Prior to the initiation of the double hauler operation, the processing machine had been processing the wood produced from one hauler (230 tonnes/day). Working a long shift (4.30 am to 5.30 pm, with two operators) the same processor is now processing over 700 tonnes/day. The use of two-staging to collect wood from two (or more) extraction operations at one point enhances the productivity of the mechanised processor. The Bell truck was being operated from 4.30 am until 6.30 pm, with two drivers (4.30 am to 11.30 am and 11.30 am to 6.30 pm).

The route travelled by the B40 in this operation was rolling, with the truck travelling both uphill and downhill, loaded and empty. Analysis of the data from this study allowed not only reporting of the production of the system as it operated, but also for the data to be extrapolated to all uphill loaded, all downhill loaded and undulating terrain over various slopes.

During the study there were times when the truck was delayed. The largest cause of these delays was the truck waiting for sufficient wood to achieve a full load. The contractor's comment was that they had had a "bad day" during the study and that "the trucks were usually not held up in this manner". The production data is therefore presented with and without delays included, representing actual observed production and potential maximum production. Figure 4 presents data for all uphill loaded extraction. Figure 5 is for the reverse situation, where all loaded travel is downhill.

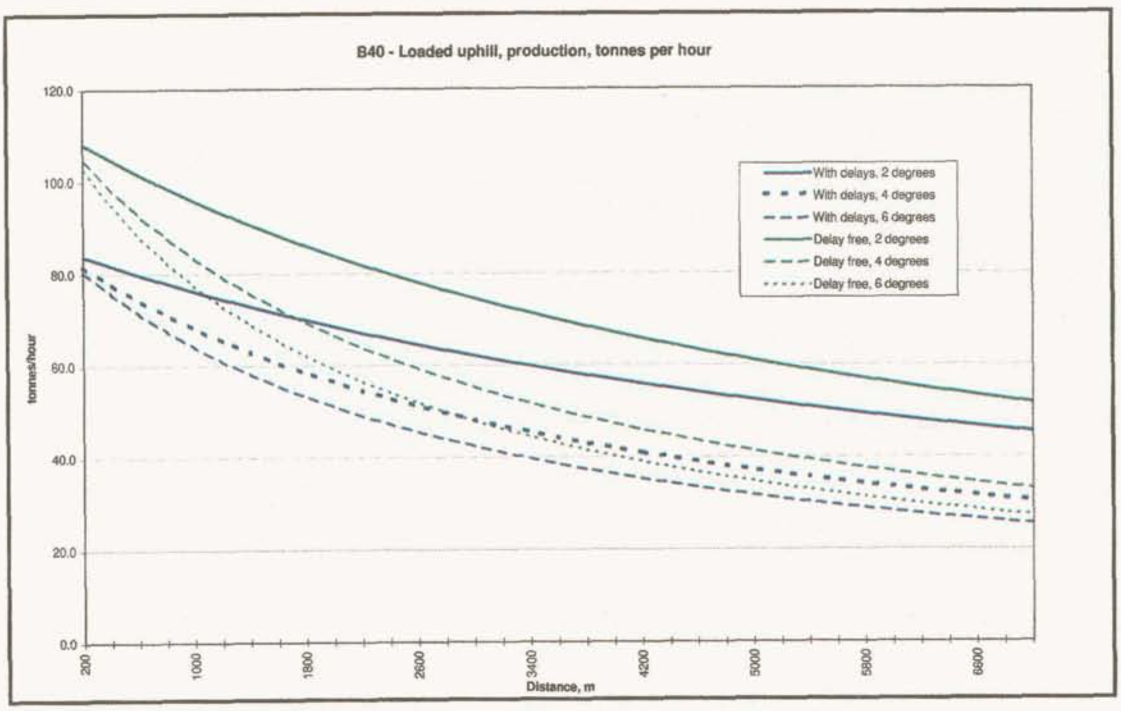

Figure 4 - Predicted production, loaded uphill with and without observed delays

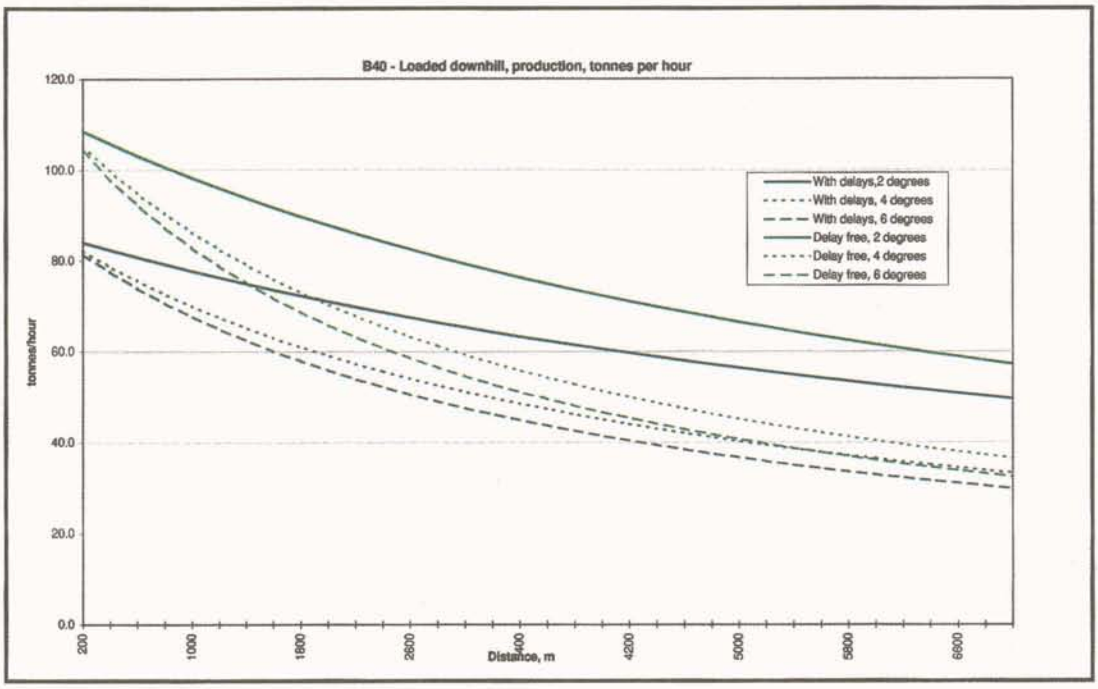

Figure 5 - Predicted production, loaded downhill, with and without observed delays

Estimated speed of the truck under various conditions (Table 1) were derived from time versus distance data and used in the production estimates.

	Uphill			Downhill			Rolling
Average Slope	2^0	4^0	6^0	2^0	4^0	6^0	4^0
Loaded	8	6	6	-	11	8	25
Empty	-	18	16	-	29	35	37

Table 1 - Bell B40 average travel speeds (kilometres/hour)

Speed of the truck was limited not only by the slope, but also by the corners in some sections. Travelling downhill loaded on the steeper slopes was slow, due to the drivers needing to keep the truck at low speeds to maintain braking and cornering control.

Travelling over rolling ridge top roads of up to 4^0 slopes was where the truck produced it highest travel speeds, loaded and unloaded. Under these conditions, the truck did not have greatly higher production over short distances than in either uphill or downhill hauls. However, on rolling roads production was higher than the other situations at longer haul distances due to the higher travel speeds (Figure 6).

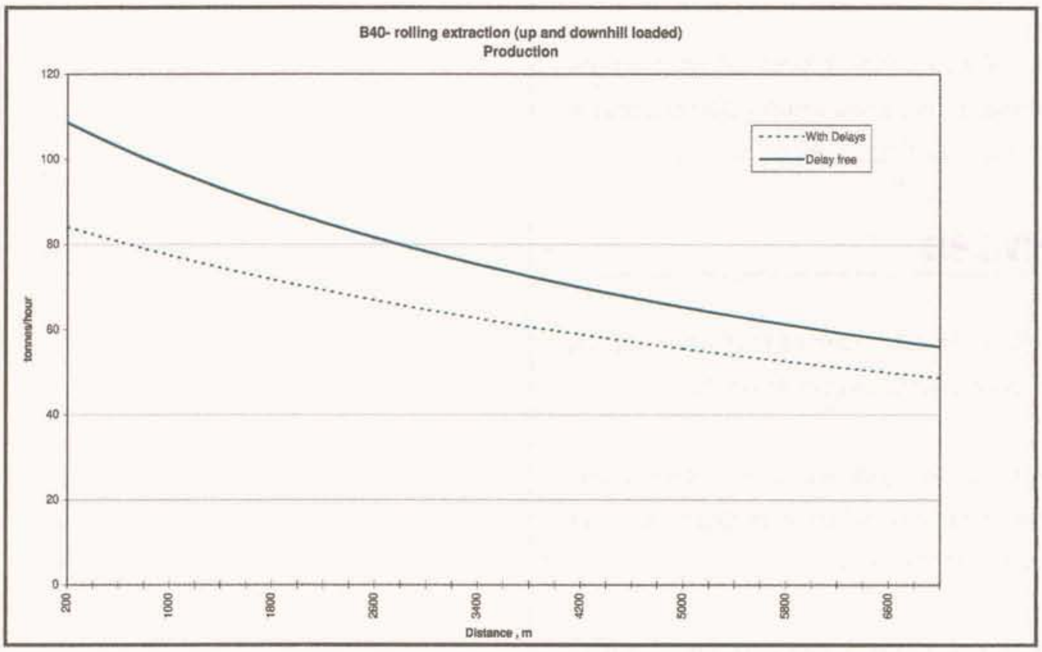

Figure 6 - Predicted production over rolling terrain with up and downhill loaded (4^0)

Discussion

To optimise the productivity of these systems, it is preferable for the trucks to be carrying the tree lengths downhill as travel speeds drop substantially when the trucks are travelling loaded uphill.

The maximum slope observed was a short section (50m) of 8^0 which was traversed loaded downhill and empty uphill. Slopes greater than this are likely to cause access and control problems with the trucks in this configuration (pole trailers).

Correct balance of the extraction, two-stage trucking and processing systems are essential to making the system work. Operating machines in the different parts of the system on different shift lengths will be necessary to attain system balance, full utilisation of all machines and even wood flow.

There are some indirect costs and benefits which are hard to measure which will also be affected by the use of two-staging. These include:

- improved safety of manual workers in the system by removing them from the extraction phase of the operation, thereby reducing their exposure to heavy machinery and live ropes

- removal of chainsaw delimbing from the operation due to mechanised processing

- reduced soil disturbance

- reduced area of productive land lost to landings and a reduction in subsequent sediment production

- the potential use of two-staging provides more options for harvest planners.

In hauler operations, the move to processing at a super-skid reduces the problem of "birds' nests" of logging residue around hill top hauler landings. However, the use of super skids concentrates the production of logging residue at a central point which can cause storage, and disposal problems and costs.

The removal of the skid workers from the system, and/or removing them from close proximity to the hauler ropes and other skid site machines reduces the frequency of lost time injury accidents (Richard Parker, Liro, pers. comm.).

The use of the super skids also allows for gains in transport productivity when logs are being taken from the super skid. The larger volumes concentrated in one area reduces the potential for part loads being left on worked-out skids, and reduces the need for split product loads. With a loader dedicated to truck loading, truck queuing (down time) can be reduced. The use of set-out or pre-loaded trailers also becomes a more realistic option. Interference between trucks and extraction machines is eliminated, with benefits for both.

In the case of the hauler operations, in most settings, there was a substantial gain in hauler output and overall system productivity associated with the introduction of the two-staging.

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