PRODUCTIVITY ESTIMATING GUIDE

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1. Introduction

This guide can be used to calculate the productivity of commonly used road construction equipment on forestry applications as applied in appraisals, Northern Interior Forest Region (NIFR). For equipment costs, the Interior Appraisal Manual (IAM), Appendix 1, based on the effective date of the appraisal, should be utilized. The appraiser is responsible for adjusting the production figures for the specific site conditions, construction procedures and specific equipment as found in the appraisal. The appraiser may modify the figures contained in this guide based on other productivity data, but he/she must clarify the reasons for the change.

Where the productivities provided within this guide do not meet the specific machine and site conditions within a given project, these rates can be used to establish a baseline for job productivities. For example, if the available equipment is smaller than listed in the tables, but still suited to the given site conditions, then the productivities may be adjusted downward. Productivities do not need to be directly interpolated from the productivities listed, with the appraiser having the ability to select a suitable rate that combines all the variables of the specific job site.

Productivity figures are based on the Engineering Manual , Estimating Guide, Chapter 3, Province of British Columbia, Ministry of Forests, 1993; Reference is also made to the Caterpillar Energy Performance Handbook, Edition 36, April 2006; and the manufacturers' work files.

Feedback and suggestions on content and format are requested from all users of this Guide. The Guide will be updated as timber pricing legislation, policies and procedures change.

2. Site Preparation

Right of Way preparation includes the removal of all merchantable and non merchantable wood. It also includes the removal of stumps, vegetation and organic soil. Clearing consists of falling, log removal, stump removal and burning or burying. Estimators can consult the applicable Interior Appraisal Manuals for falling and log removal. Stump removal and stripping productivities are estimated below.

a) Stump Removal Production

Stumps can be removed by hydraulic excavator or crawler tractor.
If the stumps are removed by hydraulic excavator, then use the following table:

Table 2.1(a) **Cycle time- Normal Productivity for Stumps removed by Hydraulic Excavator**

Stump Diameters (cm)	Cycle time per Stump (minutes)	Normal Productivity Stumps per Hour	Standard Productivity Stumps per Hour
50 – 75	0.60	100	83
76-125	1.28	47	39
126-175	1.94	31	26

NOTE:
- . Normal productivity = 100% (60 min/hr.)
- . Standard productivity=83% (50 min/hr.)
- . Rate Factor Group 27.4 to 37.0, Excavator (Cat 229, EX 300, etc)=
- . Where the overburden is <0.3 m, reduce costs (IAM Appendix 1) by 25%

Stumps up to 120 cm diameter can be removed very efficiently with crawler tractors having a power rating between 160 kw and 224 kw (ie. Cat D-8). Stumps up to this diameter do not interrupt the normal forward motion of a large tractor. Large stumps with a long tap root may require 2 or 3 passes to split the stump and remove it completely. In some cases a stump splitter mounted on the corner of the blade or ripper attachment may be needed.

Table 2.1 (b) **Productivity for stump removal by a 160 and 224 kw rated crawler tractor under good conditions.**

Stump Diameter (cm)	Normal Productivity Stumps per Hour		Standard Productivity Stumps per Hour	
	160kw	224 kw	160 kw	224 kw
Less than 60	150	300	125	250
60-90	80	120	66	100
90-120	20	30	16	25

Table 2.2 **Piling and Burning the non merchantable wood using 224 kw machine (Cat D-8, or similar)**

Slash Volume	Piling Hr. Per Ha.	Burning Hr per Ha.
Up to 150 m3 (light)	3.74	0.86
150 m3 to 300 m3 (medium)	5.11	1.21
Over 300 m3 (heavy)	7.52	1.72

b) Stripping Production

For good and average ground conditions, a tractor in the 224 kw power range is most often the most economical machine for the task.

Note: the entire clearing width is not always stripped. Deduct deep fill areas and the 3 meters adjacent to the top of the cut and adjacent to the toe of the fill from the area requiring stripping.

Table 2.3 **Stripping and burying productivity of a 224 kw (Cat D-8 or similar) tractor after all merchantable wood has been removed.**

Ground Condition	Clearing Width	Standard Productivity Ha/hr. (0.3 m overburden)
Good	30 m	0.21
Average	30 m	0.13

Standard Productivity= (50 min/hr)

Table 2.4 **Normal Stripping Productivity of a rate factor group 37.1 to 55.0 Hydraulic Excavator (Cat 235B or UH 181 or similar) with 1.5 m3 heaped capacity bucket.**

Ground Condition	Normal Productivity /Hr	
	Ha (0.7 m overburden)	bank m3 /Hr
Good	.031	217
Average	.023	161

Note: normal productivity = 60 min.
Standard productivity= 50 min

3. Primary Excavation

a) Characteristics of Rocks

Table 3.1- Identifying Characteristics of Rocks

Rock Condition	**Characteristics**
Soft	Rock is easily scarped by a knife; mark visible; hardness 1.0 -3.4 (limestone, slate, shale, mica, etc.)
Medium	Rock scraped by knife with some difficulty: faint mark, hardness index : 3.5 – 5.4 (sandstone, granite, gneiss, etc.)
Hard	Rock difficult to scrape; scanty or no mark; hardness in 5.5 – 7.0 (Basalt, etc.)

Table 3.2 **Hardness of Minerals and Rocks**

Mineral Rock	Hardness Index/Mohn's Scale	
Diamond	10.0	
Quartz	7.0	
Basalt	7.0	HARD
Chert	6.5	
Feldspar	6.2	
Gneiss	5.2	
Schist	5.0	
Magnetite	4.2	MEDIUM
Granite	4.2	
Sandstone	3.8	
Dolomite	3.7	
Limestone	3.3	
Slate	3.1	
Calcite	3.0	
Anthracite	3.0	SOFT
Marble	3.0	
Bituminous Coal	2.5	
Mica	2.3	
Gypsum	2.0	
Talc (Soapstone)	1.0	

Note: Hardness Comparison: fingernail 2+, copper coin -/+3, pocket knife blade 5+

Assumptions: For estimating purposes, the drills section assumes:

. A tank drill consisting of a compressor that operates at 17 m3/min. (600 c.f.m.) powering a rock drill with a bore drifter of 114 mm (4 ½ inches)
. Drill hole depths of 5 meters with a 1 meter collar and a diameter of 6.35 cm (2 ½ inches).
. Spacing of 2.2 m by 2.2 m.
. An explosive with a density of 1.40 g/cc (for example, Powerfrac or Dynamite C 75%, etc.)
. Primacord with safety fuse and double cap to ignite the explosive.

b) Pneumatic Tank Drills

Table 3.3 **Standard Drilling and Blasting Productivity (6.35 cm drill holes, 5 m depth, 1m collar)**

Remarks	Unit	Rock Conditions		
		Soft	Medium	Hard
Drilling				
meters per hour	m/hr	22	18	16
Cubic meters/hr	m3/h	150	86	51
Cubic meters/meter	m3/m	6.8	4.8	3.2
Drill hole spacing	m	2.6 x 2.6	2.2 x 2.2	1.8 x 1.8
Loading				
meters loaded/hour	m/h	50	50	50
Explosives				
explosives per meter	kg/m	4.43	4.43	4.43

Notes: . Estimators can alter the drilling productivity shown in the table 3.3 to reasonable values the drill and compressor is capable of producing. It is suggested that when using a 750 cfm or 900 cfm compressor, to increase the drilling productivity in direct proportion to the equipment rate.

. Standard productivity factor = 83% (50 min/hr)
. Material volumes are measured in bank cubic meters
. Explosives per blasted m3 –predetermined standard amount of explosive
. Explosive per meter - constant for 6.5 cm drill hole and explosive with a density of 1.40 g/cc.
. Meters per hour-average figures for 6.35 cm drill hole
. Drill hole spacing (m3/m, m3/h)- varies as collar depth governs amount of hole that can be loaded

c) Quarrying Rock

Rock is quarried to provide grade stabilizing material when no other material can be obtained economically. In practice, the spacing of drill holes is usually reduced to obtain better fragmentation of the shot rock. Reducing hole spacing increases costs. However, this increase is offset by the reduction of non-productive travel time and greater volume of material obtained by the increased swell factor. If use is made of blasting agents instead of stick or gel explosives, powder costs can be reduced by up to 50%.

d) Excavating Shot Rock

Use the appropriate OM unit costs for the machine used.

. Bulldozer : side cast and or movement to 40 m - Table 4.7
. Excavator : side casting and or loading out – Table 4.12
. Wheel loader : end haul and or loading out –Table 4.14

e) Ripping Material

Some materials, such as hard compacted sandy clay materials, or fractured or soft rock, are difficult to excavate by blade, so they are often loosened by ripping. The ripping cost must be compared to other methods of loosening the material (usually drilling and blasting) , on a dollars per bank cubic meter basis, to indicate if ripping is viable. Heavy ripping reduces the productive time of the bulldozer to 40-45 minutes per hour.

Ripping attachments come in various models with from 1 to 3 shanks. The most common model is the adjustable parallelogram ripper. This model allows the operator to vary the tip angle for optimum penetration and to further adjust the tip while moving. This provides the optimum ripping angle in any material.

The number of shanks used for ripping is determined by the material hardness, stratification, the degree of fracturing and the amount of decomposition or weathering. More highly consolidated material requires greater ripping force which means reducing the number of shanks. Units with more ripper shanks have a higher production capability but physical limitations restrict their application to the less consolidated materials.

In general, materials that can be scratched with a pocketknife can be ripped regardless of formation. In harder rock, the stratification and degree of fracturing must be considered to ensure that maximum ripping production is achieved.

For further information on ripping, see the Caterpillar Handbook, Ripping Section.

f) Sample Ripping Productivity

The following example assumes a 224kw machine with a single tooth ripper is being used.

Table 3.4 **Sample ripping productivity**

Factors	Hardpan	Rock
Travel speed	1-2 km/hr (20m/min)	0.9 km/hr (15m/min)
Turning Time	0.3 min	0.4 min
Ripping Distance	150 m	30 m
Depth of Penetration	0.6 m	0.3 m
Spacing Between Passes	1 m	1m
Efficiency	67%(40 min/hr)	67% (40 min/hr)
Time/Leg	150m + 0.3min +7.8 min/leg 20m/min	30m +0.4min=2.4min/leg 15 m/min
Legs/Hr	40 min/hr divided by 7.8 min/leg =5.1 leg/hr	40 min/hr divided by 2.4 min/leg 16.7 leg/hr
Volume/Leg	(150)x(1m)x(0.6m)=90 m3	(30m)x(1m)x (0.30m) =9m3
Reduced Vol/Leg1	90m3x78%=70.2m3/leg	78%x9m3/leg=7.02m3/leg
Production/Hour	5.1 legx70.2 m3/leg=358 m3/hr	16.7leg/hrx7.02m3/leg=117.2m3/hr

Notes: Volumes are in bank cubic meters.

Ripper production is highly variable, and the above should serve only as guidelines.

4. Excavating Other Materials (OM)

Other materials (OM) include all soil types which do not require drilling and blasting or the use of special equipment for excavation. Instead material is excavated using equipment like crawler tractors, hydraulic excavators, scrapers and rubber tired loaders.

For each machine, three ground conditions : good, average and difficult are defined. Productivity is provided for each ground condition.

Consider the following factors when determining the productivity of a machine:

. operator capabilities (assume an average, efficient operator with a productivity factor of 1.0)
. soil types
. Climate (as it affects soil moisture content)
. movement of material (eg. sidecast or longitudinal movement)
. optimum machine type (s) for the overall work phase (eg. if 80% of OM is best suited for crawler-tractor and 20% for self propelled scraper, base the estimate on crawler tractor unit costs unless there are sufficient earthwork volumes to utilize both machines).
. quantity of OM excavation per unit distance.

a) Crawler Tractors

A wide range of crawler tractors are employed on forest road construction throughout BC. The most common used machines have about 224 kw (300hp) c/w angle blade and hydraulic tilt cylinders.

Table 4.5 (below) defines good, average and difficult ground conditions for a 220 to 229 kw crawler tractor.

Ground Conditions	Description	Examples
Good	The material provides good traction and low rolling resistance. The climate is generally dry and the soils are well drained and easy to cut	Gravelly materials with silty/sands , loose glacial drift.
Average	Medium traction and rolling resistance. The climate is moderately damp, alternating wet and dry periods. Soil may be partly cemented or boulder. The majority of excavated materials are in this classification	Bouldery gravel, rock slide, well shot rock
Difficult	Poor traction or high rolling resistance. The climate is extremely dry or wet and material is hard to cut	Cemented glacial till or gravel, wet clay silt, fine grained sand, over-sized shot rock or rock slide, steep

b) Push Distances

Three ranges of common push distances, and the general conditions usually associated with each crawler tractor follow:

Table 4.6 **Push Distances for a 220-229 KW crawler tractor (D-8, etc.)**

Push Distance (m)	General conditions
0 – 30	Uniform terrain with some small ridges and gullies; more than 70 % of the excavated material is side cast.
30 -60	An average terrain broken up by gullies and ridges; 40 to 70% of the excavated material is side cast.
60 -120	Usually a rolling terrain, large cuts and fills required for grade construction, less than 40% of the excavated material are side cast.

Note: A crawler tractor is not efficiently utilized when the push distance exceeds 80m for OM and 40 m for rock.

c) Productivity Crawler Tractor

The following table shows crawler tractor productivity for various push distances and conditions.

Table 4.7 **Productivity for OM excavation 220 TO 229 KW crawler tractor (D-8 , etc.)**

	Good Conditions	Average Conditions	Difficult Conditions
Push Distances m	Productivity bm3/hr	Productivity bm3/hr	Productivity bm3/hr
10	416	325	244
20	316	247	165
30	269	210	158
40	227	177	133
50	200	156	177
60	170	133	100
70	150	117	88
80	134	105	79
90	119	93	70

Notes: . crawler is complete with angle blade and winch
. Volume measured is in bank cubic meters
. Standard productivity factor = 83% (50 min/hr)

d) Hydraulic Excavators

Hydraulic excavators are frequently used in forest road construction, especially where poor soil and weather create difficult conditions for a crawler tractor.

The actual site conditions may have characteristics corresponding to more than one ground condition (for example easy digging, but swing angles greater than 100 degrees). The breakdown below serves only as a guide. Exercise judgement when estimating productivity and costs.

Table 4.8 **Ground conditions for a Hydraulic Excavator**

Ground conditions	Description	Examples
Good	Wet, mostly level ground, few obstructions to mobility, easy digging bucket fills 100% to 110% of heaped capacity; swing angles less than 60 degrees no padding required	Unpacked earth, sand, gravel and material removed from ditches
Average	Wet climate, swamps, boulder grounds medium digging; bucket fills to 90% to 100% heaped capacity; some drainage concerns, restricted mobility; swing angles to 100 degrees; occasional padding	Packed earth, dry clay, soil with less than 50% rock content
Difficult	daily rain, wet broken ground, rock outcrops, swamps, seepages; obstructions to mobility; hard digging; swing angles over 100 degrees; frequent padding; bucket fills to 80% or 90% of heaped capacity	Hardpan requiring ripping, well blasted rock or shale, frozen ground, wet swampy ground

Bucket Payload

An excavator's bucket payload depends on:

- Bucket size
- shape
- curl force
- the fill factor for that soil

Fill factors for several types of material are listed below.

Table 4.9 **Fill factors for various materials**

Material	Fill Factor Range (% of heaped bucket capacity)	
Moist Loam or Sandy Clay	100% - 110%	A
Sand & Gravel	95% - 100%	B
Hard, Dry Clay	80% - 90%	C
Rock-Well blasted	60% - 75 %	D

Note: Average bucket payload – (Heaped bucket Capacity) x (bucket fill factor)

e) Productivity/Excavator

Productivity figures are based on the Caterpillar Performance handbook, manufacturer's work files, and Forest Service time studies. Cycle time covers excavating one bucket load, swinging the boom, placing the material and returning the boom.

Table 4.10 **Cycle Time and Normal Productivity (60 min/hr): Rate Factor Group 37.1 to 55.0 Excavator with 1.5 m3 (heaped capacity Bucket) (Cat 240, 225 225B, Ex270, EX 270LC)**

Ground Conditions	Minutes/ Cycle	Cycles/ Hour	Volume/ Bucket (m3)	Productivity (m3/hr)
Good	0.38	156	1.5	234
Average	0.50	120	1.4	168
Difficult	0.66	91	1.3	118

NOTE: Volumes are in bank cubic meters
Normal productivity = 60 min/hr.

Productivity is affected by other things besides ground conditions. Table 4.11 provides productivity factors for these conditions. The factor table is meant to serve only as a guide and factors may be adjusted to reflect particular job conditions.

Table 4.11 **Productivity Factors-Excavator**

Description	Good	Average	Difficult
		Ground Conditions	
		Productivity Factor	
Standard Productivity (50 min/hr)			
Travel / Maneuvering	0.95	0.90	0.85
Moving on Orders	1.0	1.0	0.95

Standard productivity figures are calculated by multiplying the productivity factors in Table 4.11 with the normal production figures in Table 4.10. The results are tabulated in Table 4.12

Table 4.12 Standard Productivity for a Rate Factor Group 37.1 to 55.0 Excavator with 1.5 m3 (heaped) capacity bucket (**Cat 225, 225B, Exc 270, EXC 270 LC, etc.)**

Ground Conditions	Productivity Factor	Standard Production (m3/hr)
Good	234 x .83 x .95 X 1.0	185
Average	168 x .83 x .90 x `1.0	126
Difficult	118 x .83 x .85 x .95	93

Note: Volumes are in bank cubic metres.

f) Rubber Tired Loaders

Rubber tired loaders are primarily used to load select secondary and surfacing material into dump trucks, but they are occasionally employed in OM excavation.

Rubber tired loaders have good maneuverability, payload capacity and travel speeds. However, effective loader operation is limited to grades of less than 6%. Steeper grades greatly reduce the travel speed and increase the risk of rolling the machine during turns. The machine also tends to create muddy conditions and deep ruts when operating in wet material. Efficient utilization of rubber tired loaders is limited to moving material over distances of less than 200 m.

g) Ground Conditions

Table 4.13 **Ground Conditions for Rubber Tired Loader**

Ground Conditions	Description	Examples
Good	The material provides good traction and low rolling resistance. The climate is generally dry and the soils are well drained and easy to cut	Gravelly materials with fines, silt-sands loose glacial drift, well shot rock, etc.
Average	Medium traction and rolling resistance. The climate is moderately damp, or alternating wet and dry periods. Soil may be partly cemented or boulder. The majority of sand, excavated materials are in this classification.	Bouldry gravel, rock slide, etc.
Difficult	Poor traction or high rolling resistance. The climate is extremely dry or wet and the material is hard to cut	Cemented glacial till or gravel, wet clay-silt, fine grain sand, oversized shot rock or rock slide, black loam, steep sidehill with toe rock, etc.

h) Productivity/ Rubber Tired Loaders

Table 4.14 : shows the time required to haul 2.5 bank m3 various distances under good, average and difficult ground conditions. Machine productivity is then taken from the graph-normal productivity vs haul distance (found in Chart IV (last page)).

Ground Conditions	Haul Distance (meters) 30 Time (min)	100 Time (min)	150 Time (min)	200 Time (min)
Good	.39	.76	.90	1.27
Average	.47	1.09	1.54	1.99
Difficult	.68	1.90	2.90	-

5. Secondary Materials

Two main factors that affect loading production of excavated material are: truck availability and the density and type of material in its undisturbed state. The more consolidated the material, the more passes of the loader are required to fill the bucket.

Productivity rates for each pit class are shown in Table 5.01. A typical cycle includes one pass of the bucket, dumping the bucket, and travel between the truck and the pit face. Loader performance studies indicate that a typical cycle takes approximately 33 seconds. If more than one pass of the bucket is required, add an extra 9 seconds to the basic cycle time for each pass. Assume that the optimum number of trucks are employed at all times.

For calculating productivities, a rubber tired front-end loader with a 3m3 bucket or a rate group factor 37.1 to 55.0 kg hydraulic excavator with a 1.9 m3 bucket.

Unit prices for loading with a hydraulic excavator are generally greater than loading with a rubber tired loader; however, the advantage of easier pit development and smaller, more frequent borrow pits may reduce transportation costs.

Table 5.01 **Standard Loading Productivity-Tired Front-End Loader, 3m3 Bucket; and Rate Factor Group 37.1 to 55.0 Hydraulic Excavator with a 1.5 m3 and 1.9 m3 Bucket**

	Rubber Tired Front-End Loader (Cat 966C, 950E, etc.)	**Hydraulic Excavator Rate Factor Group 37.1 to 55.0** (Cat E240, 225, 225B)	
Pit Class	**Productivity** m3/hr	**Productivity** in bank m3/hr Bucket Size	
		1.5 m3	1.9 m3
1	215	202	257
2	190	178	225
3	132	134	170
4	84	107	136

Notes: Table uses bank cubic meters;
Standard productivity = 83% (50 min)

a) Articulated Dump Trucks

Articulated dump trucks have a struck capacity of approximately 10 to 17 m3. They are economical for moving material up to 1000 meters when two or three such machines are used with a hydraulic excavator with at least 1.5 m3 bucket capacity.

Articulated dump trucks are preferable to regular dump trucks when:

. hauling on very soft and wet subgrade (due to their 4 and 6 wheel drive power trains)
. loading or dump areas are restricted, making turning difficult and time consuming for dump
. there is a reduced need for having a spread cat always on site.
. roads are narrow (articulated dump trucks can pass almost anywhere by using the terrain adjacent to the road).
. hauling blasted rock as it does not damage the box

b) Productivity Articulated Dump Trucks

The productivity of an articulated dump truck depends on rolling resistance and gradients. Rolling resistance varies with soil type, ground condition, moisture content, wheel loading, and the diameter and width of the tires. ***Tables illustrating rolling and gradient resistance as related to cycle times, are available in the Caterpillar Performance Handbook.***

c. Transportation

It is recognized that the most efficient and common method of hauling is by dump truck. The efficiency of truck hauling compared to other methods increases as the haul distance increases. Using tractor trailer and trailer belly dump trucks can be advantageous on long hauls and where the subgrade width is sufficient for these longer units to turn. Self loading scrapers are excellent if the load bearing capacity of the subgrade is adequate, turn -around is sufficient, and the gravel pits are easy to dig and free from large boulders. Front end loaders are used where gravel pits are located within the right of way and no more than 300 m apart. A minimum bucket size of 3.0 m3 is recommended.

The total transportation cost is the sum of the hauling cost and the fixed cost.

Fixed Costs

The fixed cost is generated from truck time lost through non-productive or non-travelling activities. These activities are:

. pit maneuvering
. loading or unloading
. turning for unloading

Table 5.02 **Times for Tandem Truck Haul-Double Lane Road with pit –run Gravel surface**

TIME (min)

Pit Class	Pit Maneuver	Load(Truck being Loaded)	Dump & turn	Total "Lost" Time per load
1	1.43	2.23	1.77	5.43
2	1.43	2.53	1.77	5.73
3	1.43	3.64	1.77	6.84
4	1.43	5.71	1.77	8.91

Notes: The total "lost" time should be added to the individual cycle time for the tandem gravel truck;
Standard productivity = 83% (50 min/hr);
To calculate standard productivity, divide total time by 0.83.
Rental rate 9.9m3 truck = $/hr(see IAM); 10m3 truck box contains 8 bank m3

Table 5.03 **Times for Truck and Belly Dump Trailer Haul – Double Lane Road with Crushed Gravel Surface.**

	TIME (min)			
Pit Class	Pit Maneuver	Load(Truck being Loaded)	Dump & turn	Total "Lost" Time per load
1 (crushed gravel in stockpile)	2.27	1.36	1.62	5.25

Notes: . Tractor and belly dump trailer 13.8 m3 loose capacity
. Rubber tired front end loader 4.6 m3 heaped
. Standard productivity = 83% (50 min/hr)
. Loose Cubic Meters used for load and haul calculations

Tables 5.04 and 5.05 show factors reflecting the effects of road gradient and road width at pit and grade unloading sites. The single lane factors cover delays at the unloading/turnaround point and at the pit due to restricted road width.

Table 5.04 **Gradient Factors for Fixed Cost-Tandem Truck Haul**

	Grade (%)	Factor
Flat	0 - 4	1.00
Moderate/steep	4 - 12	1.04
Very steep	12+	1.13

Table 5.05 **Single lane Factor for Fixed Cost-Tandem Truck Haul**

Pit Class	1	2	3	4
Cost Factor-Single Lane	1.21	1.20	1.18	1.15

Refer to Tables 5.06 and 5.07 which illustrate the average truck speeds and times over the three kilometres of overhaul. Overhaul is calculated in kilometre increments.

In the first, or working, kilometre, the distance between the pit and the unloading site varies between 1 and 999 meters. An average one way distance of 500 meters is used.

Table 5.06 **Average Haul Speeds and Return Trip Times for Tandem Trucks on Double Lane Roads; per Kilometre**

Grade %	1st km		2nd km		3rd Km	
	Km/h	min	Km/h	min	Km/h	min
Flat 0-8	34	1.76	50	2.40	64	1.87
Moderate 4-8	18	3.33	37	3.24	48	2.50
Steep 8-12	12	5.0	28	4.26	30	4.00
Very Steep 12-20	9	6.6	14	8.57	18	6.60

Table 5.07 **Average H aul Speeds and Return Trip times for Tractor and Trailer Trucks on Double Lane Roads; per Kilometer**

Grade %	1st km		2nd km		3rd Km	
	Km/h	min	Km/h	min	Km/h	min
Flat 0-8	23	2.65	67	1.79	69	1.73

For single roads, assume an additional waiting time on turnouts of 30 seconds / km.

d) Spreading

Spreading includes the bulldozer and the dump or checker man. Assume the rate of spreading for a 104 kw bulldozer (Cat D6 or similar) with hydraulic blade controls is equal to the productivity of a 3 m3 (loose) front end loader.

Gradient and width of road have only minor effects on spreading unit costs

Uses bank cubic meters, and assumes efficiency in spreading is same as loading and dependent on pit material. Standard productivity = 83% (50 min/hr)

Rental rate : 104 KW crawler tractor and dumpman

The dumpman rate is the IAM labour rate.

e) Grading

Assume a 112 KW (150HP) road grader will be used for roadway grading, and that this machine can grade and shape a 4.0 km of single lane stabilized grade in an 8 hour shift.

Grading Cost per Km = hourly rate x 8(hour shift)/ 4.0(km of single lane stabilized grade) . This cost should appear under secondary on the estimate. Grade and shape refers to grading of material and shaping the roadway prism, including the ditch slope. If only surface grading is required , productivity will increase depending on the amount of material to be graded.

f) Brushing *

Brushing involves the cutting of undesirable vegetation within the cleared right of way to restore sight distance to original specifications. The severed brush may be left on site or reduced to chips via a portable chipper

Carry out brushing during the active growing season to obtain the best results. Experience indicates that the shock to the vegetation retards growth by approximately one year.

In heavy brush, you can increase production significantly by power saw felling all stems over 10 cm in diameter.

*Refer to Detailed Engineering Cost Estimate Procedures, Northern Interior Forest Region, Effective July 1, 2006.

Chart IV : Wheel Loaders c/w 3 m3 Bucket - Normal Productivity vs Haul Distance Graph