Load and Haul Management

Load and Haul Management

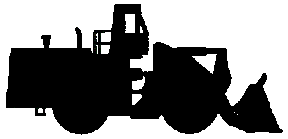
Loading and hauling operation items and objectives

- *maintain a long loading front for wheel loader operations to allow for sufficient room for all machines to work efficiently*
- *maintain shotrock loadability*
- *quarry floor maintenance:*
  - *sufficient capacity for rapid quarry floor cleanup of flyrock after blasting*
  - *adjust blasting parameters so as to avoid quarry floor humps and back-spill*
  - *keep quarry floor free of rocks from bucket spill to prevent cut tires*
  - *maintain quarry floor grade so as to ensure self drainage of water and extend tire life (quarry floor laser recommended)*
- *sort out boulders and transport to boulder stockpile for downsizing*
- *roadway maintenance:*
  - *keep roadways free of rocks from bucket spill to prevent cut tires*
  - *maintain roadway quality by frequent grading*
  - *salting or watering of roadways for dust control in dry weather / clearing snow during winter*
- *fleet maintenance:*
  - *scheduled equipment service and maintenance*
- *production reporting and work documentation*
  - *shift, weekly reports, ...*

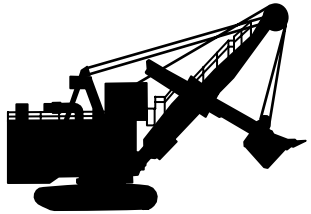
Load and Haul Management

Terminology for loading and hauling equipment

Wheel loaders (7 - 180 tonnes)



Rope shovels (300 - 1200 tonnes)



Front shovels (40 - 710 tonnes)

Articulated trucks (22 - 36 tonnes)

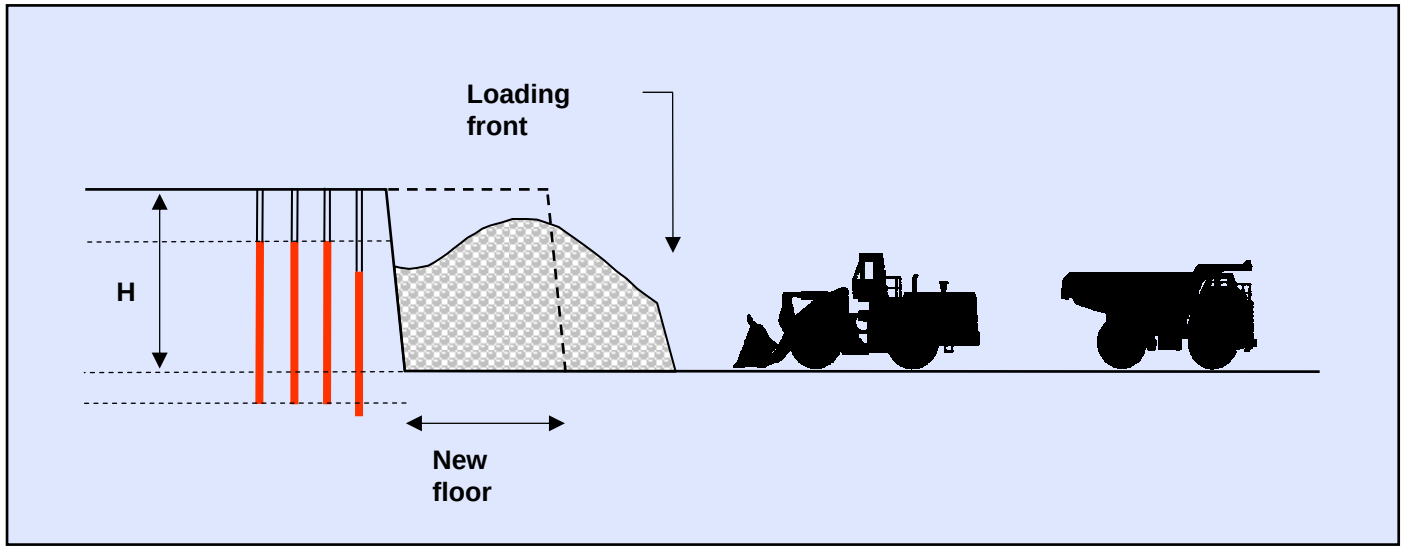
Hydraulic excavators (7 - 315 tonnes)

Trucks (32 - 335 tonnes)

Load and Haul Management

Terminology for earth moving operations

- *solid rock (bank m^3)* — *1.0*
- *shotrock in muckpile (swell %)* — *1.25 - 1.35*
- *shotrock on truck (loose m^3)* — *1.6*
- *compacted rockfill dam (dam m^3)* — *1.35*

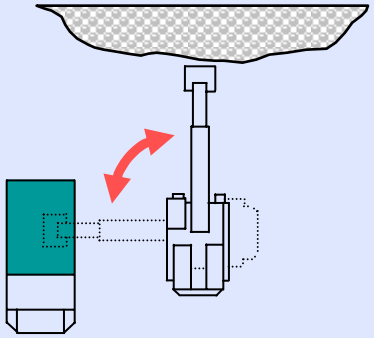


Load and Haul Management

Equipment selection

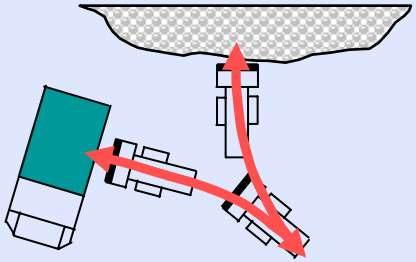
- *match gross loading capacity to primary crusher capacity*
- *match gross haulage capacity to gross loading capacity*

Front Shovels



- *capacities less influenced by poorly fragmented shotrock and tight muckpiles*
- *poor flexibility*
- *poor floor cleanup ability / requires cleanup support*
- *can load a wider range of different truck sizes more effectively than wheel loaders*

Wheel Loaders

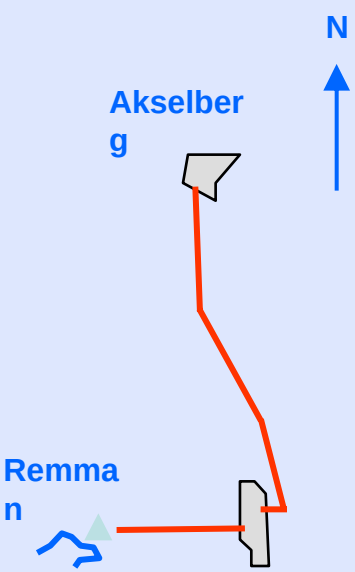


- *requires well fragmented shotrock due to large bucket size*
- *high flexibility / multiple loading fronts*
- *excellent floor cleanup ability*
- *bucket size and truck match crucial*
- *to enhance ravelling - loading front should be convex - not concave*

Load and Haul Management

Brønnøy Kalk A/S, Norway

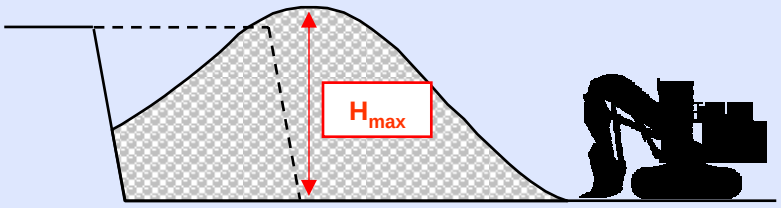
Current production levels	*1.7 Mtpa*
3 haulage tunnels	*70 m^2 x 4.7 km*
Rock type	*Marble - 2.7 g/cm^3*



Load	*1 x CAT 990 - 10 m^3 bucket* *∴ cap. > 780 / 2.7 = 290 bm^3/h*
Haul	*6 x Euclid 65 t payload* *2 x 5.5 km haul distance* *12 payloads per hour* *∴ cap. = 12 x 65 = 780 tph*
Crush	*primary jaw C160 - 1200 x 1600 mm* *primary product 0 - 300 mm* *secondary cone S6800 EC* *end-product 0 - 70 mm* *max capacity 1400 tph*
Silo	*max capacity 500 000 t*
Shiploader	*max capacity 3500 tph*

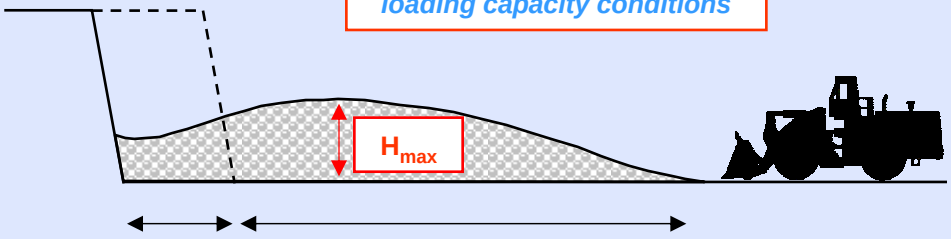
Load and Haul Management

Optimum shotrock profiles for bulk loading operations



Front Shovels	Wheel Loaders
High productivity	Low productivety
Minimal cleanup area	Muckpile too tight
Safe for operator	Muckpile too high
	Dangerous for operator

H_{max} dependent on loader size and type for optimum loading capacity conditions



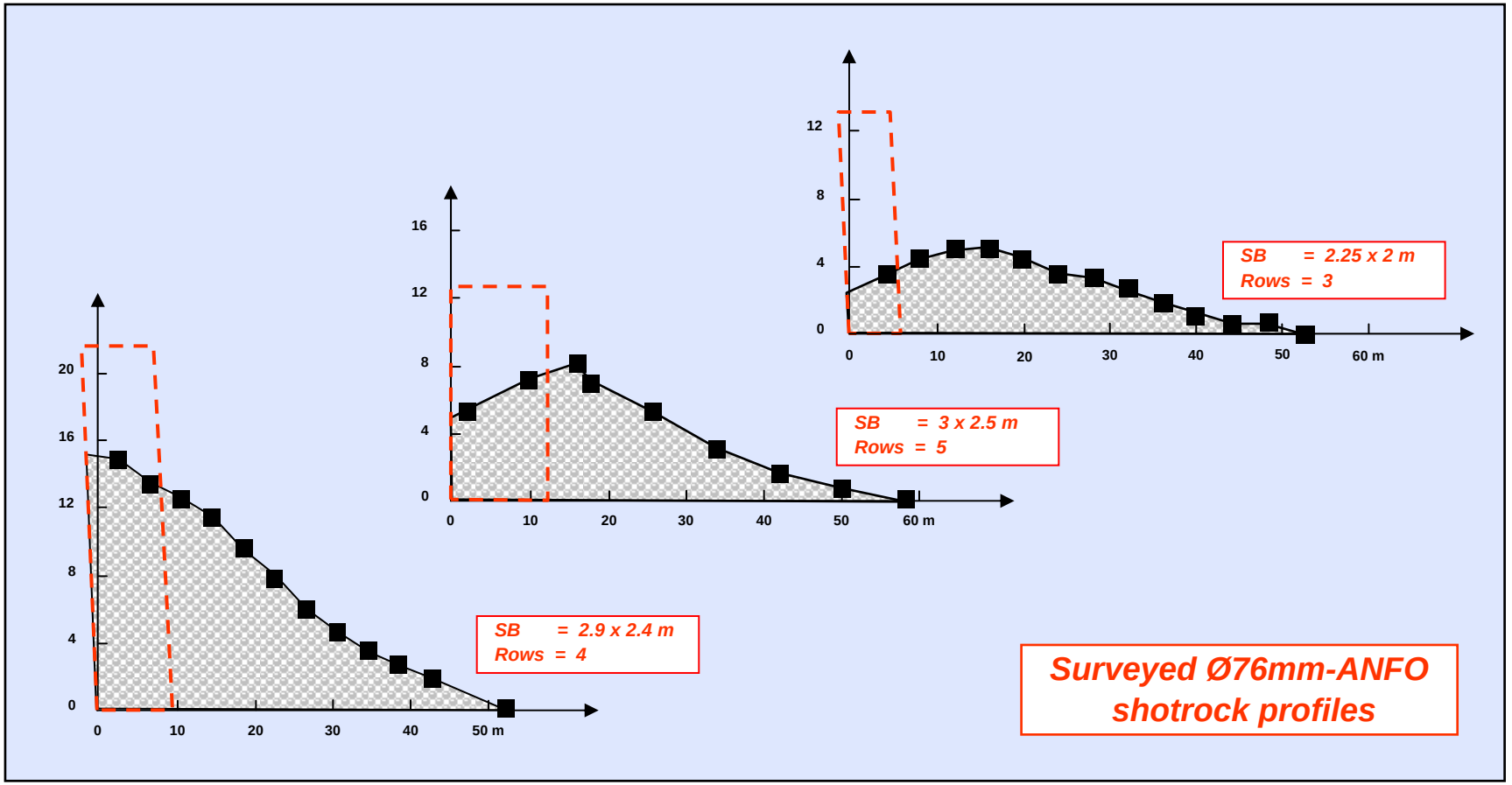
Front Shovels	Wheel Loaders
Moderate productivity	High productivety
Large cleanup area	Muckpile is loose
Safe for operator	Safe for operator

New floor (poor loadability)

Shotrock throw onto old floor

Load and Haul Management

Shaping muckpiles to maximise loading rates

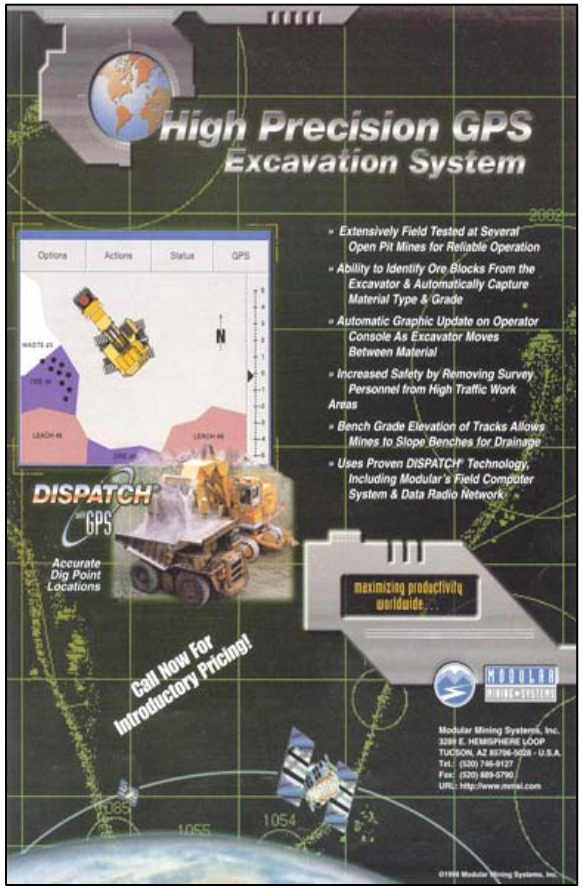


Load and Haul Management

Selective shotrock loading operations

- *for narrow and well characterised orebodies*
- *choke-blasting used to minimise ore loss and dilution*
  - *by "eliminating" forwards displacement of shotrock using low benches, multiple rows and no free face*
  - *typically shovel loading operations - with loading in flitches to further reduce ore loss and dilution*

=> blast initiation from back row
=> bench face shouldered up



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Load and Haul Management

Loading capacities

Loadability factors

- shotrock swell % versus bucket penetration force and bucket fill %
- shotrock fragment size versus bucket size
- loading front shape and occurrence of ravelling / hazardous ravelling
- loading front height versus loader size
- loading on new floor (wheel loaders)
- occurrence of floor humps

Net loading capacity components

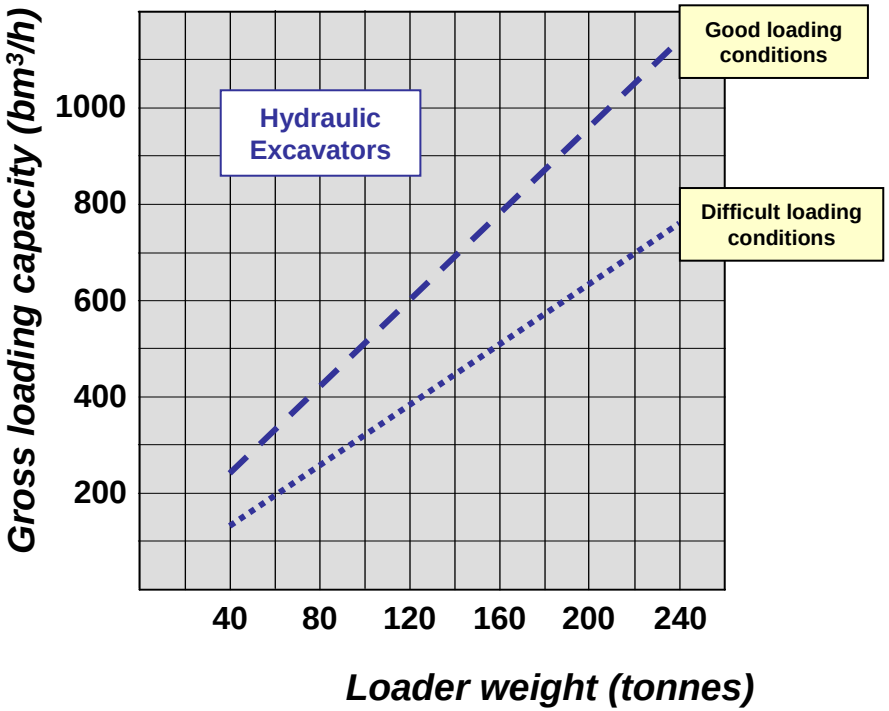
- bucket filling
- drive / swing to truck
- bucket dumping
- drive / swing to loading front

Gross loading capacity components

- in addition to **net loading capacities**
- sufficient space for rapid positioning of truck for bucket dumping
- trimming of loading front
- extraction of boulders
- levelling of quarry floor and bucket spill cleanup
- repositioning along loading front (shovels and excavators)

Load and Haul Management

Loading capacities

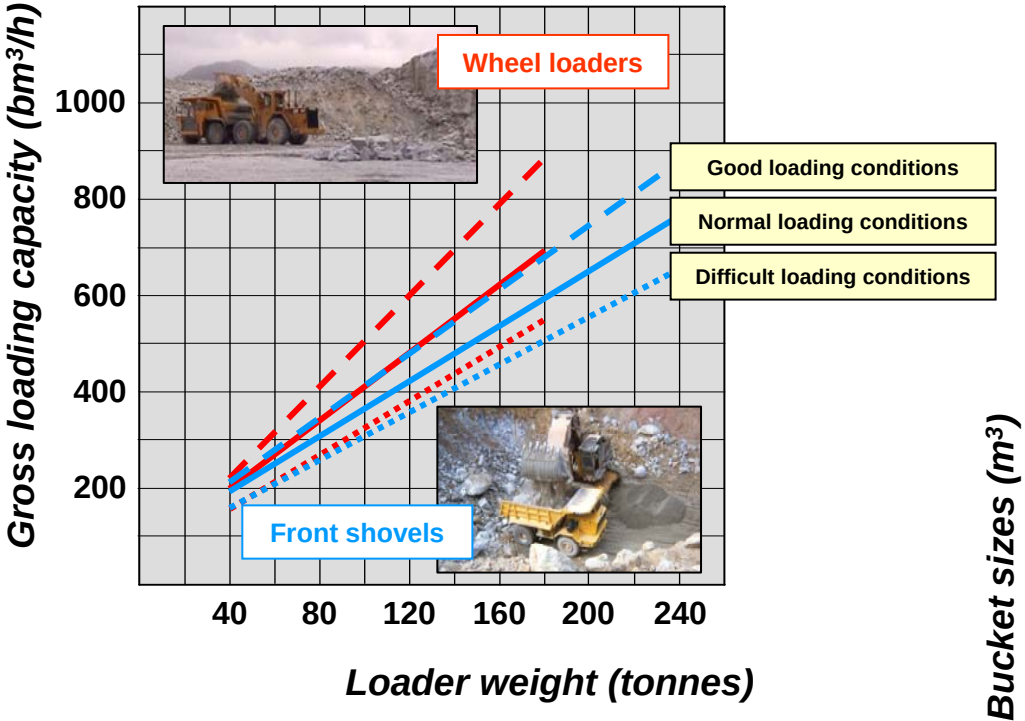


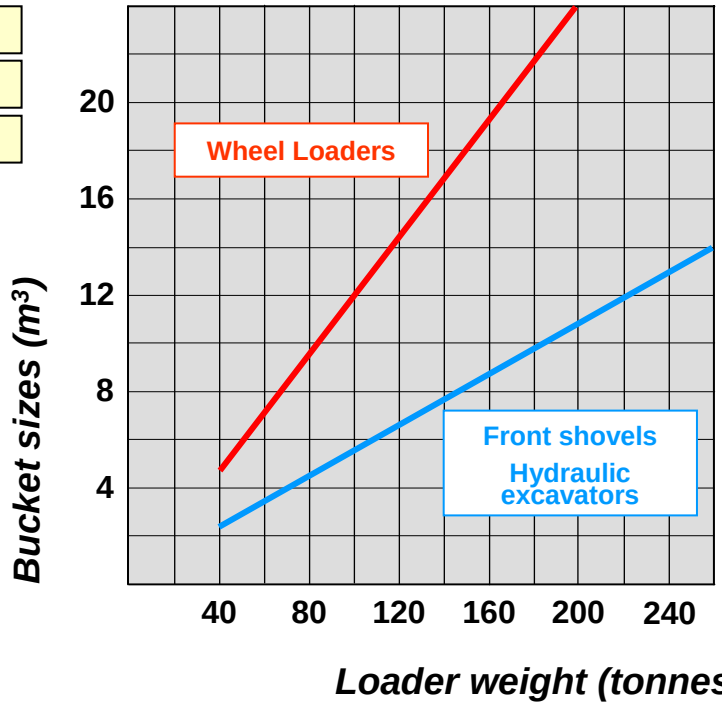
Difficult loading conditions requires additional time for:

- *trimming loading fronts*
- *sorting boulders*
- *cleaning around floor humps and toes*
- *poor shotrock diggability*

Load and Haul Management

Loading capacities



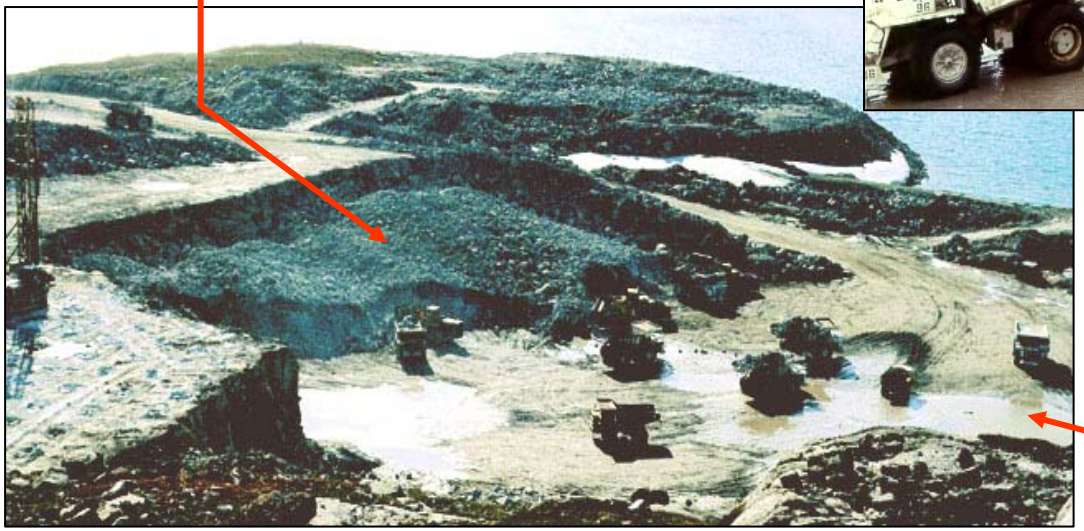


Load and Haul Management

Loading operations

Muckpile too high for optimum wheel loader operations - resulting at times in a dangerous ravelling of the loading front

Long loading front with sufficient work space for all machines



Optimum muckpile height for 96 tonnes wheel loaders

Water puddles - poor quarry floor grade control

Load and Haul Management

Loading operations

Auxilliary machines required for quarry floor cleanup after blasting for loaders with poor mobility

Typical toe problem requiring auxilliary hyd. excavator work and/or use of secondary blasting

Tight muckpile with poor diggability due to insufficient heave and throw (or poor liberation of rock fragments)

Load and Haul Management

Haulage capacities

Individual truck cycle times

- *time at loading front (queuing at loading front and gross loading capacities)*
- *travelling time*
  - *roadway geometry (segment lengths, grades, rolling resistance, corners, passing, …)*
  - *truck rimpull-speed-gradeability and brake performance curves*
- *dumping time at primary crusher, pre-primary surge pile, tip, …*

Gross haulage capacities

- *truck payload capacity*
- *truck cycle times*
- *number of trucks in operation*
- *slack in cycle times*

Load and Haul Management

Load & carry case study

Summary

Boulder sorting occurrence	*~ 1 in 6 cycles*
Roadway cleanup occurrence	*~ 1 in 6 cycles*
Net cycles per hour	*31*
Boulder sorting sequences per hour	*5.2*

Net load & carry capacities

	(bm^3/h)	(tonnes/h)	(min/cycle)
• *as measured*	*146*	*408*	*1.93 = 1.25 + 0.68*
• *normalized downtime*	*148*	*415*	*1.90 = 1.23 + 0.67*
• *no downtime*	*188*	*525*	*1.50 = 1.01 + 0.49*
• *boulder downtime only*	*164*	*458*	*1.72 = 1.23 + 0.49*

Loader	**CAT 988**
Bucket volume	**8 lm3**
Bucket filling	**~ 85%**
	(bucket fill % versus roadway cleanu
Quarry floor conditon	**uneven, new snow, slippery**
Transport distance	**~ 85m**
Primary crusher opening	**950mm**

Cycle time (min)	*Loading & to crusher (min)*	*Tip & to muckpile (min)*	*Comments*
2,50	2,08	0,42	Trim face - sort boulders
1,21	0,75	0,46	
1,45	0,95	0,50	
1,50	1,00	0,50	
1,50	1,09	0,41	
3,55	0,92	2,63	Cleanup of roadway to crusher
1,12	0,62	0,50	
1,50	1,08	0,42	
3,08	2,50	0,58	Trim face - sort boulders
1,63	1,13	0,50	
1,95	1,42	0,53	
3,00	2,45	0,55	Trim face - sort boulders
1,88	1,38	0,50	
1,79	0,92	0,87	Cleanup of roadway to crusher
2,00	0,67	1,33	Cleanup of roadway to crusher
1,75	1,25	0,50	
1,42	1,00	0,42	
1,93	*1,25*	*0,68*	***Avg.***

Load and Haul Management

L & H for inpit crushing

Inpit crushing allows for alternative haulage methods than for stationary primary crushing plants

- *load & carry to inpit primary crusher*
- *conveyor transport from inpit primary crusher to crushing plant*