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Masters project
Mining Engineering

KUMBA
IRON ORE

ANGLO
AMERICAN

CALCULATION OF SECONDARY EQUIPMENT DUE TO THE NEEDS OF PRIMARY EQUIPMENT

Sishen, 21 July 2007

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1 Foreword

In order to calculate a mining project, the main machinery like loading machines and hauling machines are calculated very exact, due to the needs of the project. The supporting equipment is determined subjectively or based on experience. This was the reason for the mismanagement and a chance to abolish.

If this project is a success it will be used for applying more machinery and will be used as an explanation why these machines are needed. The expectations of Kumba Iron Ore and Anglo American plc are quite high due to reducing, the amount of machinery, or having a reasonable explanation why more machines are needed.

A program like this is not known in the Anglo American plc group. Therefore the following lines have to be obeyed:

It is hereby declared that Christian Comoli created this master project all by himself, using the mentioned references in chapter 10 and data from Kumba Iron Ore's Sishen Iron Ore Mine.

This program is the first one of its kind and it is strictly prohibited to copy or adapt.

The data mentioned in this project is classified as company secret and it is forbidden to give it to third persons or to publish them.

This master's project was created in association with Kumba Iron Ore, which is the holder of the copyright privileges.

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Christian Comoli
The autor

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Hannes Cronje
Manager Mining

2 Problem assignment

The purpose of this calculation model is to calculate the necessary amount of secondary equipment.

For a better understanding what the calculation model is about, it is important to know what primary and secondary machinery is. Primary machinery is equipment used for loading and hauling, like large rope shovels, excavators, front-end-loaders and large trucks. The secondary machinery is supporting the primary equipment. This means they are mainly used for supportive works, like cleaning operational areas of primary machinery, as for example loading and dumping areas, or maintaining roads. Typical machines of this category are wheel- and track-dozers, graders, smaller trucks and smaller front-end-loaders.

The problem until now was, that there is only a subjective coordination of the secondary equipment resulting from reports of primary machine operators and foremen. So it happened that the machines are only working, when they are ordered to and had to go around the whole mine to their destination.

To face this unproductive situation the relation between the secondary and the primary machines had to be studied and coordinated in a way of optimisation. The primary and secondary machinery have to work continuously together. This means that there will be specified secondary machinery working aside with one or more specified primary machinery or at one or more specified areas.

The output of this optimisation will be a certain amount of secondary machines necessary to support the primary machinery. It will display where which machine has its operational area. The calculation model has to have a global design. This means it must be useable for the whole mine as well as only for one region. This is required to use it for both long-term and short-term planning. The idea is to use it within the 18 month planning to forecast, how many machines will be necessary and for the weekly planning to specify which machine have to be used where.

The additional task will also be to put out the working hours, the fuel consumption, the usage of water for dust control and the amount of HMS for surface maintenance.

It is quite a challenge to build up an idea for a program which is able to determine an amount of machines. The main problem is the big operational variety, the different types of machinery and the interaction of them.

3 Executive summary

The purpose of this project is to create a program that is calculating the necessary amount of supporting machinery due to the needs of primary machines.

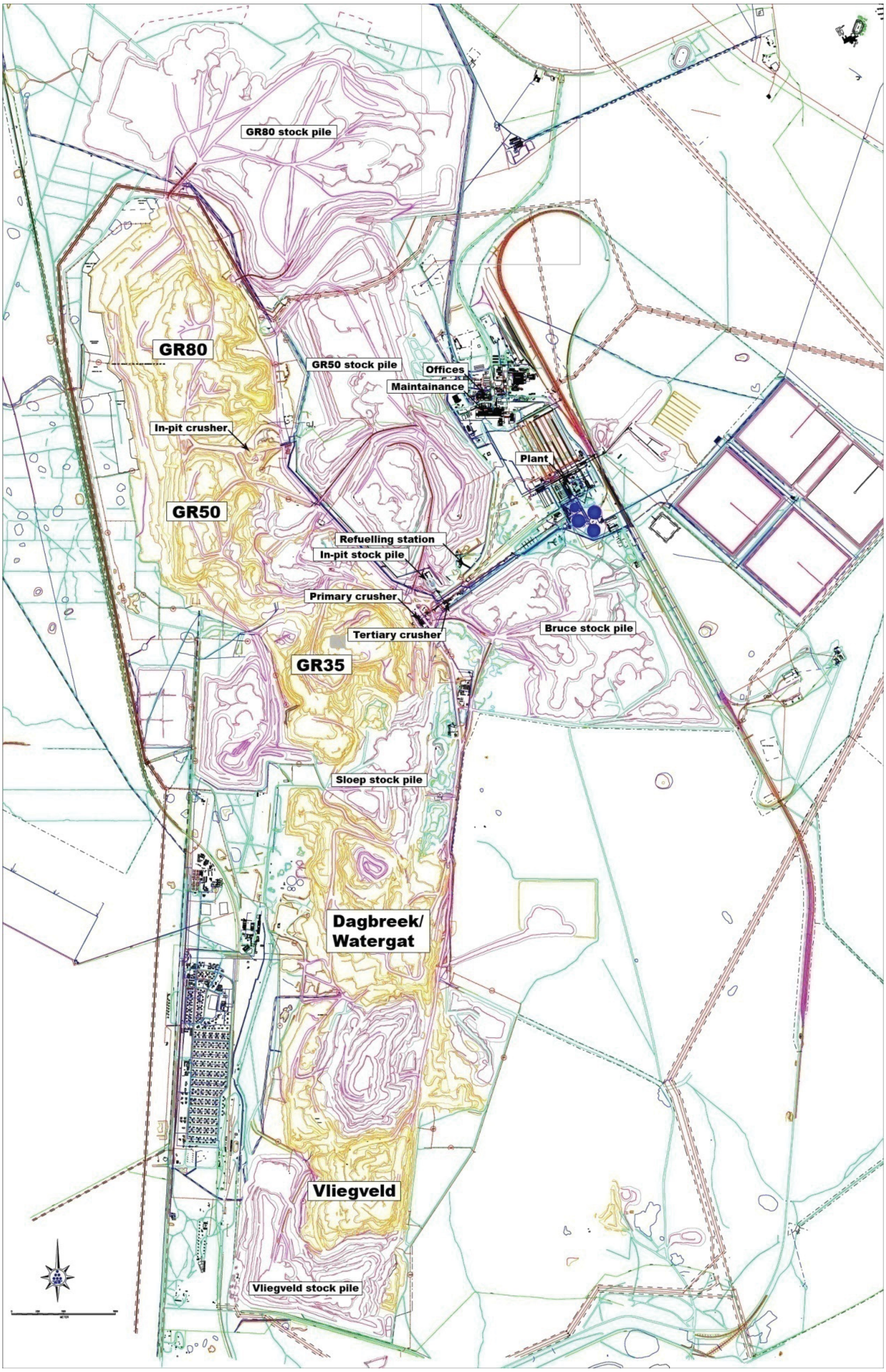
In order to fulfil this assignment it was required to split the project into two parts. A complete site study and the second was the programming itself.

The site study’s output gives a complete overview of the mine. It displays all primary equipment, all the secondary equipment and their mode of operation. Further on the position of the shovels was evaluated and displayed on a map. Its problem is that it is only a snap shot, because the shovels are moving from one loading block to the next. The site study also describes the layout of the mine with its areas, the roads between and in the areas as well as the stock piles.

The program itself uses the information from the site study to express the relations between the secondary machinery with and primary machinery, the stock piles and the roads. The program determines the time needed to do the machines specific work, under using machine specific settings and performance data. This time is compared to the work time per shift and out of the time consumption the amount of machines is calculable.

The results for each machine are displayed on separate sheets. These sheets also contain the work time of each machine, the fuel consumption and the amount of material handled.

4 Situation description



P 1: Global overview of Sishen Iron Ore Mine

Sishen Iron Ore Mine and Thabazimbi Iron Ore Mine are owned by Kumba Iron Ore. Anglo American plc is the main stockholder of Kumba Iron Ore with 67% of the shares.

The Sishen Iron Ore Mine is divided in five sections from north to south. Main roads are connecting the five sections with the offices and secondary roads lead the way in and through the sections. The current operation is taking place in the southern part of the pit the Vliegveld and Dagbreek/ Watergat region. It is a very challenging area, because it consists mainly of massive ore, with banded iron formations and clay layers in between. The other three regions from South to North are GR35, GR50 and GR80. In GR35 and GR80 the operation is mainly concentrated in removing the top soil in order to prepare these regions for further mining operations.

This operation is done by Moolman Bros. in the GR80 area. They are using two RH200 electrical face-shovel excavators which load ten CAT 777C,D,E and four CAT 789C mining trucks.

P 2: Moolman Bros. Terex (O&K) RH200

P 3: Moolman Bros. CAT 789C

P 4: Moolman Bros. CAT 777D

The clay layers in GR35 are removed by Tau Mining. This company is using two Liebherr R984 Litronic backhoe excavators, one Hitachi EX1800 backhoe excavator. These machines load fifteen Euclid EH1600 and Terex TR100 mining trucks. The mine in this part will be expanded in the north direction.

P 5: Tau Mining Liebherr R984 Litronic loading a Terex TR100

P 6: Tau Mining Hitachi EX1800 loading a Euclid EH1600

The company Hitricon is removing the top soil in the Dagbreek/ Watergat area to expand the mine in the western direction. They are using a CAT994D front-end-loader, one Liebherr R996 Litronic face-shovel excavator and a Hitachi EX1800 face-shovel excavator. For the hauling the company uses one Liebherr T262, four Liebherr T282 and six Euclid EH3500 mining trucks.

P 7: Hitricon Liebherr R996 Litronc loading a Liebherr T262

P 8: Hitricon Hitachi EX1800

P 9: Hitricon Liebherr T282

P 10: Hitricon Euclid EH3500

The production planning divides the geology in six basic material types. Material A is a high grade ore with Fe content above 60%. The B material's range is from 54 to 60% Fe content. Below 54% Fe content the material is classified as waste material. The waste is divided in C material with Fe content from 40 to 54%, D material below 40% and E material which is mainly clay. There is also an L material existing, which is banded ironstone with Fe content above 58,5%.

A closer specification for the different material types is enclosed in appendix 9.1].

The banded ironstone can't be used for production at the moment, but it will be treated in the SEP (Sishen Extension Project). The SEP includes a new jig plant, as addition to the existing beneficiation plant, which will process complicated ore like L material and lower graded material like B material. The SEP-plant will start working on a test-run by August 2007.

At this stage there are three rope-shovels working at Vliegveld and three in Dagbreek/ Watergat. One rope-shovel is working in GR35 and the other one in GR50 to extend the mine to the north. The main loading machines are P&H 2300XPB. These machines have a weight of about 850t and a bucket capacity of about 25m^3. With the average density of hematite iron ore in this pit of 3200$^{kg}/_{m^3}$ the bucket capacity is approximately 64t per load. About 40 Komatsu 730E with a payload of about 190t and 10 Lectra Haul (Unitrig) MK36 trucks, with a payload of about 170t, are used for hauling the material to the primary or in-pit crusher, as well as to the different stock piles. There is almost a stock pile for each material type in every region. Four front-end-loaders for a quick change of the loading area are available. There are different types of front-end-loaders, one CAT994C, with a bucket capacity of about 12m^3, one CAT994F, with a bucket capacity of about 16m^3 and 4 Komatsu WA1200-3, with a bucket capacity of about 20m^3. Further on there are two Demag 485 hydraulic shovels working on the mine, one at Dagbreek/ Watergat and one at GR50. Their bucket capacity is circa 28m^3. These machines are being supported by eleven Wheel-dozers, ten track-dozers, six graders, three front-end-loaders, five trucks, five water-trucks, two low-beds, two cable handlers, and two excavators, equipped with hydraulic hammers. This fleet of secondary machines will be extended in August by three wheel-dozers as well as six track-dozers.

The face is 12,5m high and there is normally one rope shovel loading the ore or the waste on the trucks. Trucks are assigned by dispatch to the ore or waste shovels, to avoid separate circuits. The dispatch typically tries to commission three to four trucks to one shovel. If the loading place or the haulage routes are uneven or stones are lying around, the shovel operator or the truck operator has to report this hazard to the primary dispatch. The primary dispatch will report the situation to the secondary dispatch, which has to coordinate the right machinery to the specific place to clear the reported hazard. The problem with this system is that the secondary dispatch doesn't know exactly where the machines are and what the operators are doing.

They often report being busy or having defects, so that the dispatch is forced to use another machine which is available further away.

An even bigger problem is the shift system. There are four shifts, which work twelve hours a day and the operators are always working with the same machine at the same area, or with the same shovel operators. This means that some of the secondary machines drive around the whole mine to work with their normal primary machine operator, instead of staying with the current machine.

Some machines like water-trucks are seldom controlled by the dispatch, so they actually can do what they want. They are ordered to water the road continuously the whole shift.

This is a very unproductive situation and has to be changed.

5 Accomplishment

The first step to accomplish this task was to do a complete site study to know how the equipment is operating and how different types of machinery are working together.

The main task of secondary equipment is to support primary equipment and the building and maintaining of roads and ramps. To start this program it was necessary to separate the different tasks and workplaces of each machine. This means that it's better to use a track-dozer on a stock pile than a wheel-dozer and it is more efficient to use a wheel-dozer at a loading area compared to a grader.
A track-dozer is used for rough pushing jobs. In contrast to the mode of operation of a track-dozer a wheel-dozer is used to even out floors and push stones to the side. The main job of a grader is to maintain roads and it is not used for pushing.

According to practical experience a front-end-loader doesn't need a wheel-dozer for the cleaning of the loading zone, because it can clean it itself. Until now, the operators of front-end-loaders didn't clean their operational area from fallen stones, so secondary machinery was used unnecessarily.

Another point which has to be taken into consideration is that at least one machine of the different kinds and a spare one for maintenance and refuelling reasons should be in each of the working areas. The distances to the maintenance shop and the lubrication station are quite far and therefore a spare machine has to be in place to take over the refuelled machines duty.

It is very inefficient to drive a track-dozer from one working area to a different location, because it will use plenty of fuel and it takes a lot of time. For the calculation it's a must to make use of the two existing low-bed's to transport the dozers and the excavators, equipped with hydraulic hammers from one place to another.

Another thing which has to be taken into account is that wheeled machinery has to go to the lubrication station to refuel. The maximum distance to the station is about

7km. The machinery has to go at least once a day to the refuel station. The machines equipped with crawlers are getting refuelled by two fuel-trucks.

A big problem, as already described, is the coordination of the machinery at this time, so secondary machines are currently standing around and waiting for an order to go to a certain primary machine or certain place.

Most of the loading areas especially in the South part have uneven floors. To prepare these places HMS (Heavy Medium Separation), which is waste material from the cyclone plant with a size smaller than 6,3mm, is used. Furthermore this material is used to prepare dumping zones at stock piles and secondary roads. This material is loaded by secondary front-end-loaders on secondary trucks, which haul the HMS from the stock pile Bruce to the loading and dumping areas.

It must be compulsory that the calculation relates a certain secondary machine to one or more primary machines, roads or building areas. All machines are provided with a unique number, so a certain secondary machine will be related to one or more primary machines.

6 Site study

The output of the site study will be a specification of each machinery, road and stock pile used within the calculation program. Every machine has a specific work and a work habit to fulfil its duty. This part will describe the primary machines, secondary machines, as well as the location and condition of roads and stock piles.

A list of all equipment is enclosed in appendix 9.2].

6.1] Primary Equipment

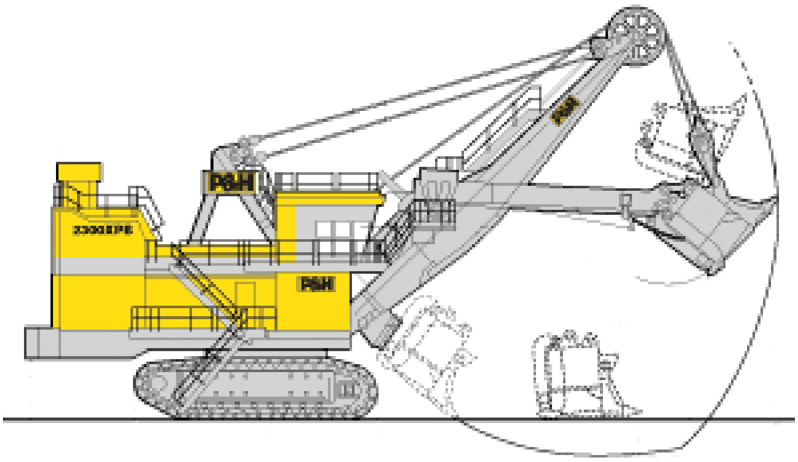
This section will describe the different primary machinery, what they look like and what their tasks are. The primary equipment is supported by the secondary machinery.

6.1.1] Rope-shovels

Type: 8x P&H 2300XPB (#560-567)

These machines have a crawler chassis with a 360º turn-able body. The dipper is rigidly mounted on two sticks which are connected with a gear to the boom. This boom is fixed to the body on the lower side and adjusted via ropes on the top side. The sticks can be lowered via a rope and moved back and forward via a gear. This is a very critical part of the rope-shovel, because there is a force concentration on the gear. The dipper has a flap to release the material. The machines are powered electrically. The drivers cab is on the right side of the boom.

The rope-shovels mode of operation is dominated by pushing and lifting. The dipper is lowered to the ground and pushed with the stick in the material. Through continuously retrieving the hoist the bucket is pushed upwards through the material.



P 11: Digging curve of a P&H 2300XPB(P&H, 2002)

P&H 2300XPB	
Engine:	2970kW
Weight:	774,4t
Bucket capacity:	25,20m^3

P 12: P&H 2300XPB (#567) in GR35

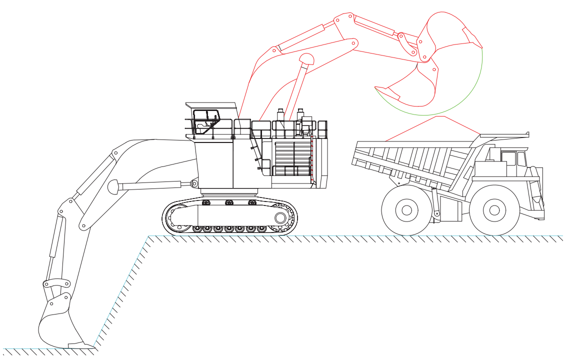
These machines are only used for loading the primary trucks with waste or ore. The operational areas floor condition can get worse due to some falling stones from the bucket or of the truck. It is not possible for the shovel to clean the places themselves so they need to be supported by secondary equipment.

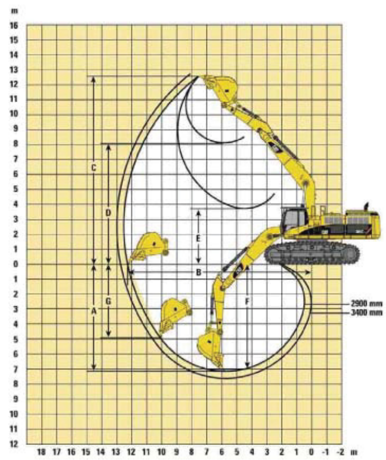
6.1.2] Hydraulic face-shovel-excavators

Type: 2x Demag 485 (#22, #23)

These machines are big hydraulic excavators equipped with a face shovel. They are equipped with crawler chassis with a 360° turn-able body. The boom is mounted on the chassis and can be lifted vertically by two hydraulic cylinders. The hydraulic cylinders are located underneath the boom. The stick is mounted on the boom and can also be lifted vertically by two hydraulic cylinders. These cylinders are mounted underneath the boom and at the middle of the stick. The bucket is fixed on the stick and is move-able vertically up- and downwards. The cylinders to push the bucket are mounted underneath the stick. The bucket has a cylinder controlled flap release. The machines are powered electrically. The drivers cab is right at the side of the boom.

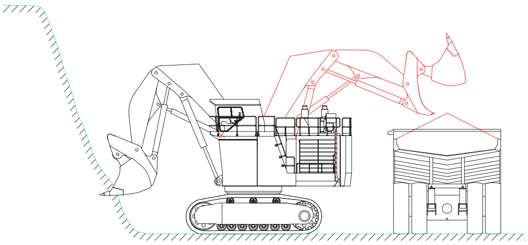
The stick and boom design of a face shovel is different to a normal backhoe excavator, because the backhoe design has the hydraulic cylinders over the boom to press the stick towards the machine. The face shovel's design is different, because the cylinders push the stick away from the machine. This is decreasing the possible breakout force. A second difference is the way how the bucket is forced into the material, a backhoe bucket is really digging the material underneath and a face shovel is pushed in the material in front of it. The following pictures show the difference between the working routines.

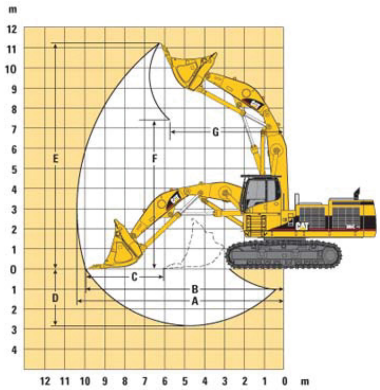




P 13: Mode of operation of a backhoe excavator (Komatsu, 2007)

P 14: Digging curve of a CAT 385C backhoe shovel (Caterpillar, 1998, 2007)

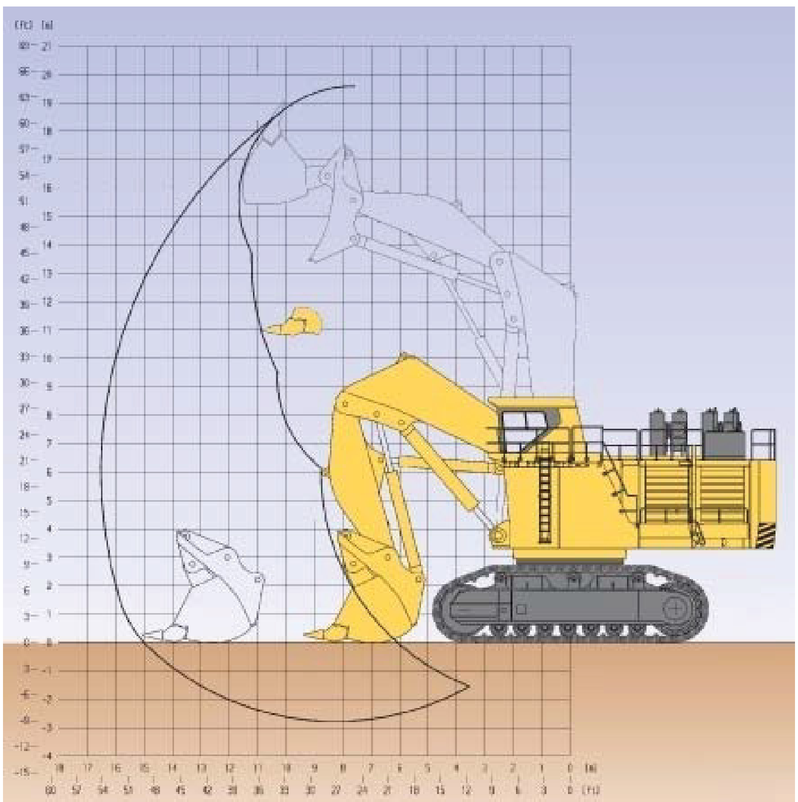




P 15: Mode of operation of a face-shovel excavator (Komatsu, 2007)

P 16: Digging curve of a CAT 385C face shovel (Caterpillar, 1998, 2007)

The benches at Sishen Iron Ore Mine are faced and therefore the usage of face shovel excavator is essential. The mode of operation as described is that the machine pushes the bucket mainly with the stick cylinders in the material. Through raising the boom and rotating the bucket upwards, the bucket is filled with material.



P 17: Digging curve of Demag 485 (Komatsu, 2007)

Demag 485	
Engine:	940kW
Weight:	500,0t
Bucket capacity:	28,00m^3

P 18: Demag 485 (#22) in GR50

These machines have the same tasks and problems as rope shovels.

6.1.3] Front-end-loaders

Type: 4x Komatsu WA1200-3 (#570- 572, #580)

2x CAT 994C, F (#35, #582)

These are articulated wheeled machines with a lift-able bucket at the front. The machine uses a four wheel drive. One axis with the engine and the drivers cab is connected with the articulated joint to the second axis with the bucket and the lifting system. The bucket is mounted on two sticks which can be lifted vertically by two cylinders. The bucket can be turned up and down by a cylinder in the middle of the stick cylinders. The articulated design allows the machine to turn at an angle of about 45° whilst standing. The wheeled running gear makes the machine very flexible.

The mode of operation of this machine compared to the other two is completely different. The machine is not standing during the loading operation. It drives into the material and keeps pushing the bucket into the material during the bucket is turned upwards and lifted at the same time. The main forces are concentrated on the front wheels, which experience a high wear of the tires due to the abrasiveness of iron ore. This is the reason why chains are used on the front wheels.

P 19: Digging curve of a CAT 994F (Caterpillar, 1998, 2007)

Komatsu WA1200-3	
Engine:	1280kW
Weight:	205,2t
Bucket capacity:	20,00m^3

P 20: Komatsu WA1200-3 (#571) in GR50

CAT 994C	
Engine:	932kW
Weight:	176,2t
Bucket capacity:	12,00m^3

P 21: CAT 994C (#35) in Vliegveld

CAT 994F	
Engine:	1176kW
Weight:	184,4t
Bucket capacity:	16,00m^3

P 22: CAT 994F (#582) in GR50

These machines are used for loading the primary trucks with waste or ore. It is possible for them to change the loading point quite quickly. Front-end-loaders don't need to be supported by secondary equipment, because they can clean their loading points themselves.

6.1.4] Trucks

Type: 10x Lectra Haul (Unitrig) MK36 (#204, #207-215)

40x Komatsu 730E (#514-553)

The primary trucks are normal rigid off-highway trucks. The machines have a rigid body with two axes. The back axis has four wheels with electrical wheel engines. The machine has two power systems, a diesel engine which is coupled to a power generator and a pantograph system to drive on a power-line. The front axis is the steering axis and is not powered. The drivers cab is in the front on the left hand side. The cab is protected by the buckets shield against falling stones from the top during loading. The dump body is turn-ably mounted on the back of the body and can be lifted with two hydraulic cylinders underneath the dump body. The engine is placed directly underneath the driver's cab.

The mode of operation of a truck is only being loaded, driving and dumping. In order to use the machine properly and with care it should not be overloaded, the material should be placed in the middle of the bucket, the speed should be properly adjusted and the road conditions should be good. The driver has to take care not to drive over stones or boulders. This could harm the body and the tyres seriously.

P 23: Driving and Dumping of a Komatsu 730E (Komatsu, 2007)

Lectra Haul (Unitrig) MK36	
Engine:	1073kW
Speed:	50,8km/h
Payload:	145,0t

P 24: Lectra Haul (Unitrig) MK36 (#214) in Dagbreek

Komatsu 730E	
Engine:	1491kW
Speed:	55,7km/h
Payload:	183,7t

P 25: Komatsu 730E (#516) in Dagbreek

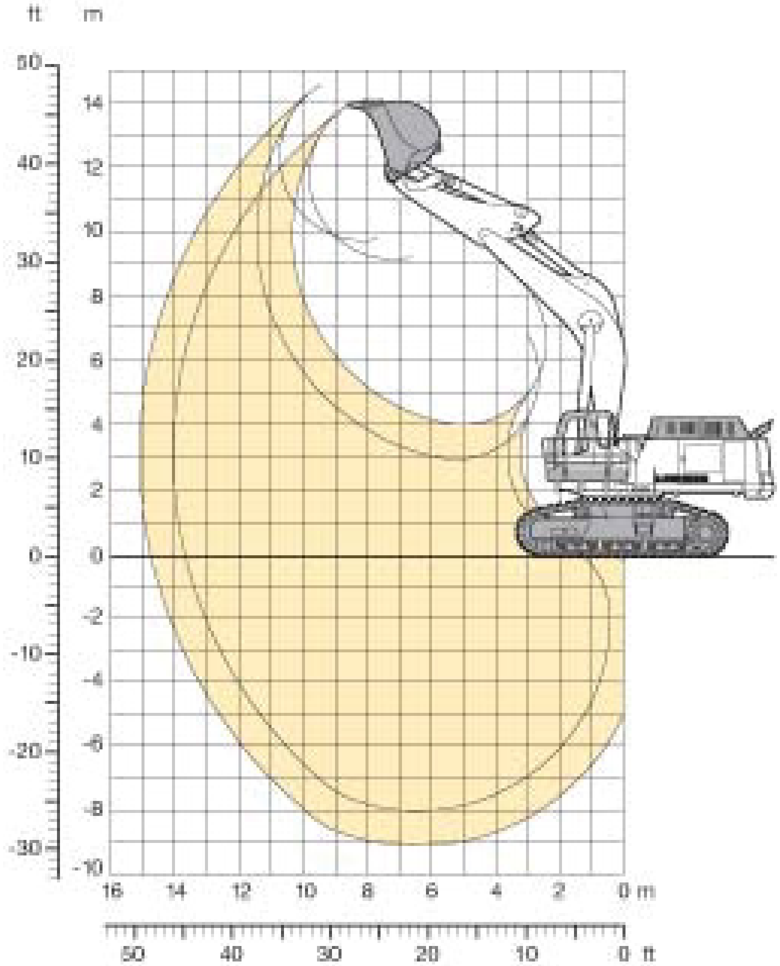
The haul trucks are used for transporting waste or ore from the pit to the crushers, the stock piles or the waste dumps. The roads used by the trucks must be maintained by secondary equipment in order not to harm the tyres of the trucks.

6.1.5] Hydraulic backhoe-excavators

Type: 1x Komatsu PC1250 (#572)
2x Komatsu PC1100 (#573, #574)
1x Liebherr R984 Litronic (#578)

The looks of the hydraulic backhoe excavator is the same as the face-shovel excavators, except of the stick and bucket configuration. The stick cylinder is mounted on top and the middle of the boom and is connected to the end of the stick. The same system is used to open and close the bucket. The opening of the bucket is orientated towards the machine.

As previously described, in chapter 6.1.2], these machines work normally on the material in order to pull the material towards it. They are working on blasted or loose material, so they have to build their own plateau to work properly. The crawler chassis allows it to climb loose material piles.



P 26: Digging curve of a Liebherr R984 Litronic (Liebherr, 2007)

Komatsu PC1250-6	
Engine:	485kW
Weight:	106,7t
Bucket capacity:	4,90m^3

P 27: Komatsu PC1250-6 (#574) in Dagbreek

Komatsu PC1100-3	
Engine:	423kW
Weight:	86,1t
Bucket capacity:	4,10m^3

P 28: Komatsu PC1100-3 (#573) in Vliegveld

Liebherr R984 Litronic	
Engine:	523kW
Weight:	119,8t
Bucket capacity:	6,00m^3

P 29: Liebherr R984 Litronic (#578) in GR80

These machines are used for selective mining. They separate the waste from the ore. Normally a track-dozer is doing the pre-separation on selective blocks, but there is no need for a secondary machine afterwards.

6.2] Secondary Equipment

In this section the different secondary machines are being described, what they look like and what their tasks are. The main machines of the secondary equipment fleet are those, which are constantly in use. This will be wheel-dozers, track-dozers, graders, water-trucks, dump-trucks and front-end-loaders. The others listed below are only used for certain jobs and not continuously.

6.2.1] Wheel-dozers

Type: 8x CAT 834B (#024-03, #316-324)

3x Komatsu WD600-3 (#401-403)

Wheel-dozers are light articulated wheeled machines with a small blade in front. The blade can be adjusted in the vertical direction. The machine uses a four wheel drive. One axis with the engine and the drivers cab is connected with the articulated joint to the second axis with the blade and the blade's hydraulic system. There is one hydraulic cylinder in the middle of the axis for lifting the blade. A frame, which is protecting the tyres, is used as a base construction for the blade is mounted on the front axis. The two cylinders mounted on the frame are used for turning the blade forward and backward.

Due to the wheeled design these machines are very flexible and quick. The mode of operation is cleaning the areas in stripes. The wheel-dozer drives forward, lowering the blade and cleans the stripe. The blade is raised again and the machine drives backwards, making a slight turn to reach the next stripe for cleaning.

CAT 834B	
Engine:	336kW
Speed:	34,1km/h
Weight:	46,4t
Blade capacity:	7,75m^3
Fuel capacity:	630l
Fuel consumption:	34,66l/h

P 30: CAT 834B (#323) in Dagbreek

Komatsu WD600-3	
Engine:	389kW
Speed:	33,1km/h
Weight:	42,9t
Blade capacity:	11,5m^3
Fuel capacity:	670l
Fuel consumption:	35,85l/h

P 31: Komatsu WD600-3 (#403) at Bruce stock pile

The wheel-dozer is basically used for floor maintaining at loading areas and stock piles. It’s a light vehicle for pushing light material, like HMS. The wheel-dozer is quite fast in his cleaning action, so it will interrupt the loading of the primary machines only for a short time. It is also used to clean at stock piles with material of a low density, like D or E material.

Problem:

The rough floor conditions and the abrasive material are increasing the tyre wear. This machine tends to overheat, because of the construction the air filter clogs because of dust very quickly. Due to this problem the availability of the machine is very low. Because of the extreme abrasive material the blade’s wear is quite high.

6.2.2] Track-dozers

Type: 10x CAT D10R (#039-05, #303-311)

6x CAT D10T (#430-435)

These are heavy crawler machines with a big blade in front. The crawler is designed in a delta shape to be able to go through abrasive material. The special layout of the CAT track-dozers is that the drive gear is located underneath the cab and so that it is not reaching in the material, the drive gear and the two gears on the ground form a delta crawler, to keep it away from damage. The blade can be adjusted in the vertical direction. It is possible to adjust the blade at an angle in the blade plane. The machine is a rigid construction with the blade in the front and a ripper in the back. The drivers cab is located in the back of the machine. In front of the cab is the engine. On the frame of the engine there are two hydraulic cylinders to adjust the blade and force the blade in the material. The cylinders can be used differently in order to achieve an angle in the blade plane. The track-dozer has a very strong frame mounted left and right on the body. This construction is used to protect the crawlers as well as for lifting the blade. Two cylinders are used to turn the blade forward and backward.

The mode of operation is equal to the one of the wheel-dozer, only that the track-dozer is not pushing the material in stripes for cleaning, but pushing bulk material for one place to another or over the edge.

CAT D10R	
Engine:	425kW
Speed:	8,3km/h
Weight:	66,1t
Blade capacity:	22,00m^3
Fuel capacity:	1109l
Fuel consumption:	31,66l/h

P 32: CAT D10R (#309) at Vliegveld stock pile

CAT D10T	
Engine:	433kW
Speed:	12,7km/h
Weight:	66,4t
Blade capacity:	22.00m^3
Fuel capacity:	1204l
Fuel consumption:	--,--l/h

P 33: CAT D10T (#432) at Maintenance

The track-dozer is used for rough conditions. Its primary task is to push material at the stock piles over the edge of the bench. Further on, it is used to build the road bed of roads and ramps. Another important task is the roughly cleaning of blast blocks in order to prepare them for the entering of the drill rigs, ripping toes in order to improve the floor condition and pre selection of material on a selective mining block.

Problem:

The utilisation of the blade is far below 100%. This means the blade is not used to push the full amount of material possible. It is rather used for pushing on a certain side. The hydraulic cylinders suffer under the one sided forces. Even the crawlers are affected during this mode of operation. The wear on the web plate is higher than it should be and due to the extreme abrasive material the blade's wear in general is quite high.

6.2.3] Graders

Type: 6x CAT 16H (#022-06, #022-07, #240-243)

A grader is a machine to even out the surface. The grader has a big blade between the first and the second axes mounted on a boom. This blade can be adjusted in every direction possible and it can be adjusted very exactly. At the back of the machine, a puller is available for ripping the roads. The machine's layout can be divided into two parts the main part with the engine in the back, driver's cab and the two powered axes. The second part consists of the boom with the blade and the third steering axis. Underneath the boom there is a rotary assembly with the blade mounted on it. The assembly is 360° turn-able. It is connected to the boom at the third axis. The rotary assembly is connected to two hydraulic cylinders which can adjust the assembly and the blade at any angle in the blade plane. The cylinders are mounted on the boom. A third cylinder mounted on the assembly can move it back- and forward. This cylinder is mounted on the boom at the edge to the drivers cab.

The mode of operation of a grader is compare able to the wheel-dozer It is maintaining the roads in stripes. The machine grades a certain road part, drives back and grades the next stripe.

CAT 16H	
Engine:	205kW
Speed:	44,5km/h
Weight:	24,8t
Blade width:	4,88m
Fuel capacity:	492l
Fuel consumption:	12,93l/h

P 34: CAT 16H (#241) in GR35

The grader is mainly used for maintaining the secondary roads. The machines are not allowed to grade the primary roads because a contractor is used for road maintaining there. Further details to the work of this contractor are given in chapter 6.4.1]. Its second use is building the top layer of streets and ramps. This machine should not be used in rough conditions.

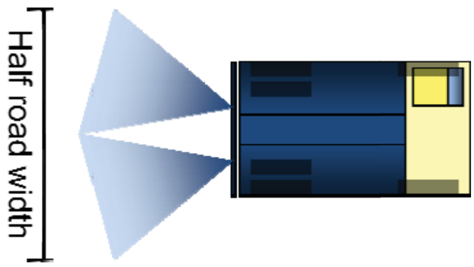
Problem:

Because of the extreme abrasive material the blade's and the tyre's wear is quite high.

6.2.4] Water-trucks

Type: 5x CAT 777C, D (#222, #224-226, #231, #235)

This machine is an adapted rigid dump-truck with a water tank instead of a bucket. The technical issues are described at the chapter 6.2.5]. The tank is equipped with a pump and two nozzles in the back. The hydraulic cylinders for lifting the bucket have been removed too. The water tank is steeply mounted on the body. The water-truck driver has the opportunity to choose either to use both of the nozzles or only one.

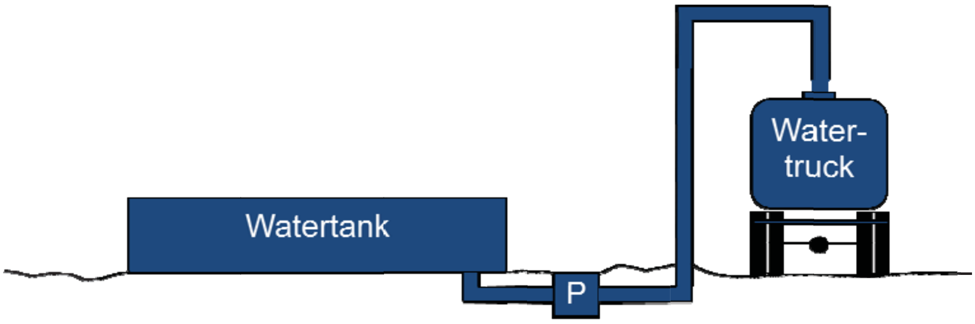


P 35: Water-truck spreading

P 36: CAT 777C water-truck (#231) spraying at Bruce stock pile

The mode of operation of the water-truck is quite easy to describe. The machine is driving around the whole mine and is spraying water on the roads.

The tank volume is 85m^3. So the truck has to refill from time to time, there are six refilling stations spread around the mine. The refilling stations consist of a water-tank, a pump and a pipe which is mounted on the top of a mast.



P 37: Refilling station

P 38: Refilling point in Vliegveld

If the truck is coming to refill the driver has to place the machine directly underneath the pipe and has to switch on the pump manually. The problem with this is first of all, that it takes quite a while to place the truck underneath the pipe and secondly the operator doesn't know when to stop exactly, so there is always a certain amount of water overflowing.

CAT 777C, D	
Engine:	746kW
Speed:	60,0km/h
Weight:	161,0t
Water capacity:	85m^3
Pump rate:	0,52l/m²
Fuel capacity:	1137l
Fuel consumption:	43,30l/h

P 39: CAT 777D water-truck (#226) in Dagbreek

The machine is only used for watering secondary roads for dust depression. It is not allowed for the machine to water primary roads, because a contractor is used for dust suppression there. Further details on this theme are described in chapter 6.4.1]. One important fact which has to be taken into account is seasonal changes with a peek in summer.

Problem:

There are no reportable problems to describe. The only thing what should be taken into consideration is the way how the roads are being watered.

6.2.5] Dump-trucks

Type: 5x CAT 777D (#232-234, #236)

3x Komatsu HD785-7 (#237-239)

The secondary dump-trucks are as well as primary trucks normal rigid off-highway trucks. The basic construction issues are mentioned at chapter 6.1.4]. The only difference to the primary trucks is that the secondary trucks don't have electrical wheel engines. The truck is powered by a diesel engine which is coupled directly to the back axe.

The working of the machine is like the primary truck. It gets loaded at Bruce stock pile by a CAT 990C and drives from there to the different areas in the mine to deliver HMS for floor maintenance.

CAT 777C, D	
Engine:	746kW
Speed:	60,0km/h
Weight:	161,0t
Bucket capacity:	60,5m^3
Fuel capacity:	1137l
Fuel consumption:	39,60l/h

P 40: CAT 777D (#234) at Bruce stock pile

Komatsu HD785-7	
Engine:	895kW
Speed:	65,0km/h
Weight:	166,0t
Bucket capacity:	60,0m^3
Fuel capacity:	1308l
Fuel consumption:	--,--l/h

P 41: Komatsu HD785-7 (#237) at Bruce stock pile

It is mainly used for transporting HMS material to the loading and dumping sites.

Problem:

There are no reportable problems.

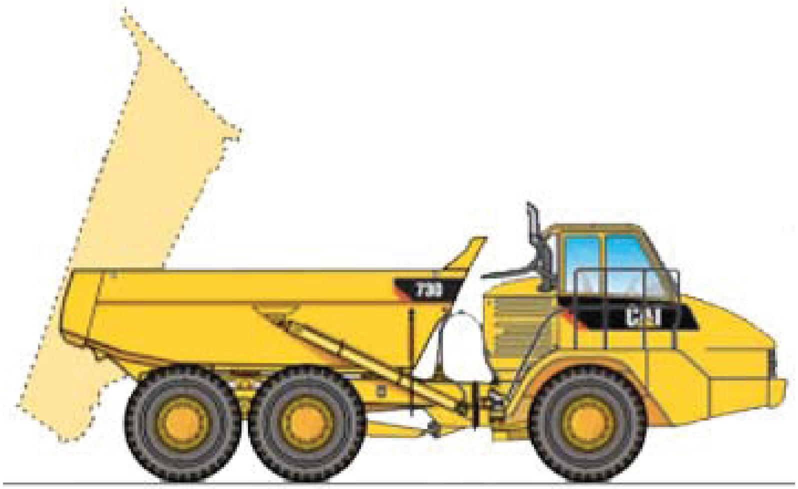
6.2.6] Articulated dump-trucks

Type: 2x CAT 730 (#162, #163)

The operator's cab with the powered and steer-able axis and the engine are connected with the articulated joint to the two back axes with the bucket. The bucket can be turned at the articulated joint at a 360º angle compared to a fixed cab part.

P 42: Demonstration of the turn ability of an articulated dump-truck (Caterpillar, 1998, 2007)

The bucket can either be lifted by two hydraulic cylinders mounted on the back frame or the bucket is equipped with an ejector.



P 43: CAT 730 with a lift-able bucket (Caterpillar, 1998, 2007)

P 44: CAT 730 with a ejector bucket (Caterpillar, 1998, 2007)

Due to the wheeled driving gear and the articulated design the machine is very fast, flexible and easy manoeuvre-able. This flexibility makes the machine a bit instable, because the machine is roadworthy and due to payload of 28,1t the machine is narrow and high. It can happen that the bucket is rolling in uneven floor conditions.

CAT 730	
Engine:	242kW
Speed:	51,3km/h
Weight:	51,0t
Bucket capacity:	20,6m^3
Fuel capacity:	360l
Fuel consumption:	20,50l/h

P 45: CAT 730 (#162) at maintenance

Those machines are currently used to transport HMS from outside of the pit into the pit. It is loaded at the plants stock pile and transported to Bruce stock pile.

Problem:

There are no applicable problems.

6.2.7] Front-end-loaders

Type: 3x CAT 990C (#134-01, #340, #341)

1x CAT 966H (#161)

This is an articulated wheeled machine with a lift able bucket in the front. The construction is similar to the one of the primary front-end-loaders in chapter 6.1.3]. The machine is only a bit smaller than the primary ones.

The mode of operation is complete the same as for the primary due to the fact that it is the same type of machinery. The only difference might be that the material handling is easier for the CAT 990C according to the fact that HMS is a coarse material with a certain grain size distribution. According to the specifications the HMS material is not as abrasive as blasted iron ore, so the usage of a protection chain can be avoided.

CAT 990C	
Engine:	466kW
Speed:	22,5km/h
Weight:	73,5t
Bucket capacity:	8,4m^3
Fuel capacity:	970l
Fuel consumption:	42,79l/h

P 46: CAT 990C (#134-01) at Bruce stock pile

CAT 966H	
Engine:	164kW
Speed:	38,8km/h
Weight:	21,3t
Bucket capacity:	3,8m^3
Fuel capacity:	377l
Fuel consumption:	15,20l/h

P 47: CAT 966H (#161) at the blending beds

These 990's are mainly used for HMS loading onto the secondary dump-trucks. The smaller front-end-loaders are used for loading the articulated dump-trucks and for loading and hauling to and at the beneficiation plant.

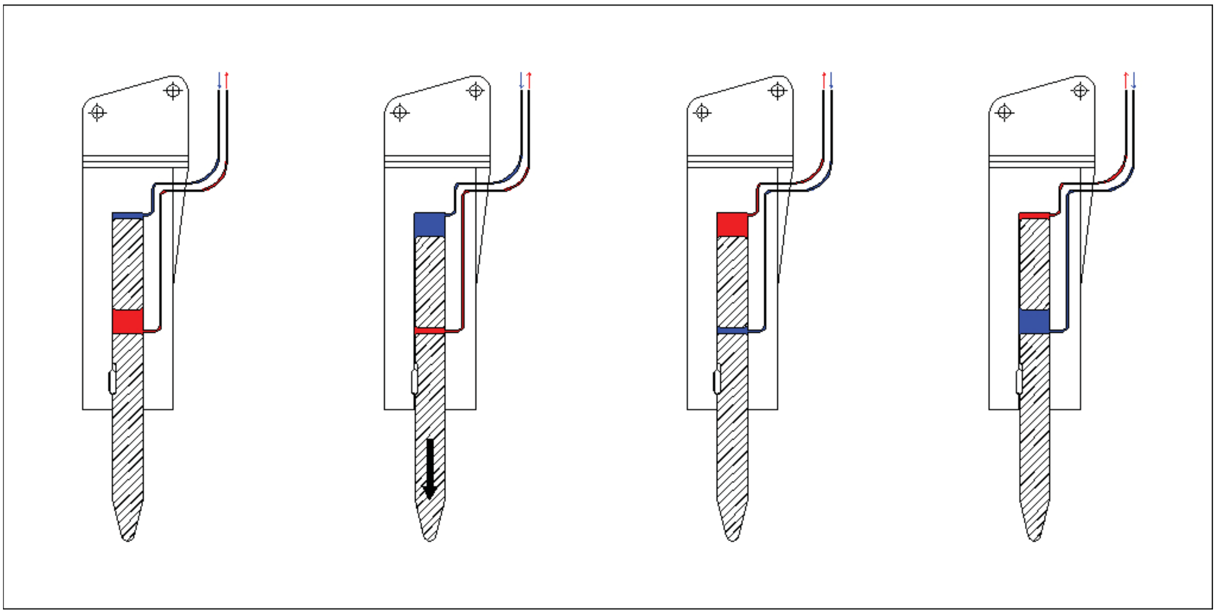
Problem:

The bigger front-end-loaders are quite old, causing an increase in maintenance.

6.2.8] Excavator equipped with hydraulic hammers

Type: 2x CAT 375 LME + Rammer City G130 (#357, #371)
1x CAT 385C LME + Rammer City G130 (#373)

This is a normal backhoe excavator as described in 6.1.5]. The only difference between the selective mining shovels and this excavator is that these machines are equipped with a hydraulic hammer instead of the dipper. The move-ability of the hydraulic hammer is the same as the one of the normal dipper. The only additional equipment needed is a hydraulic valve to connect the hammer to the machine. The hydraulic hammer is a Rammer City G130. The functionality of the hammer is quite simple. The system is working with two valves, the one opens and presses the steel rod down after that the other valve is opening and presses the steel rod back. This working cycle is done 400 times per minute. The steel rod is tapered at the end to concentrate the force on the material to be crushed.



P 48: Working principle of hydraulic hammers

This excavator is used to crush big boulders which can occur after blasting, due to weak zones, faults, joints or misfire. The excavator lowers the hammer on the bolder and activates the hydraulics. Due to the hitting ratio and the weight of the hammer, a huge force is yield on the boulders surface, causing cracks and chipping of stones. Those stone experience a high acceleration and spread in all directions and can cause serious damages and injuries. The hit rate of the hammer induced vibrations which cause micro cracks in the material and lead to a total failure of the stone and as a result the breaking of the boulder. The excavator induces the described stresses on different points of the boulder in order to weaken the whole structure.

P 49: CAT 385L equipped with a hydraulic hammer (Caterpillar, 1998, 2007)

CAT 375 LME	
Engine:	319kW
Weight:	78.9t
Hammer weight:	7.0t
Hit rate:	400bpm
Fuel capacity:	990l
Fuel consumption:	14,71l/h

P 50: CAT 375 LME (#371) in Dagbreek

CAT 385C LME	
Engine:	390kW
Weight:	85.8t
Hammer weight:	7.0t
Hit rate:	400bpm
Fuel capacity:	1240l
Fuel consumption:	--,--l/h

P 51: CAT 385C LME (#373) in GR35

The three excavators are mainly used in the southern part of the mine to split boulders, which sometimes occur after blasting.

Problem:

Due to the vibrating forces the crawlers, the boom and stick cylinder's wear is very high and the mechanical part, especially the rotating assembly, suffer under this situation.

6.2.9] Cable-handlers

Type: 2x CAT 834B (#024-01, #024-06)

This machine has the same body as the wheel-dozer, but it is equipped with a rotating cable drum. This machine is basically the same as the wheel-dozer, as described in chapter 6.2.1], the only difference, is that the blade and the frame for the blade are missing. It has two hydraulic cylinders in the front mounted on the front axe to lift and lower a cable drum. The cable drum itself is equipped with an electrical wheel engine in order to spin the drum and roll on or off an electric cable. This electric cable is used to power the rope-shovels, the hydraulic shovels and the drills.

Their main task is helping moving primary equipment. Due to the fact that primary loading machinery and the drills are powered electrically they have to be supplied by a power cable. In order not to damage the machinery they have to be moved before blasts or when changing the operational area. The electric cables have a diameter of about 5cm, so they are too heavy to transport manually. The cable-handler is used at this stage to roll up the extension cables and move it further. The primary machines itself have a cable drum as additional equipment.

CAT 834B	
Engine:	336kW
Speed:	34,1km/h
Weight:	46,4t
Blade capacity:	7,75m^3
Fuel capacity:	630l
Fuel consumption:	33,36l/h

P 52: CAT 834B cable-handler (#024-06) in GR80

This machine is only used when an electric powered shovel or drill has to be moved.

Problem:

Actually, the same problems as those of the wheel-dozers occur, except for the tyre wear.

6.2.10] Low-beds

Type: 1x CAT 793B with TowHaul low bed (#132-01)

1x Dresser 210M (#131-02)

A low-bed is basically the body of a rigid off-highway truck without the bucket. The technical specifications are equal to those of the primary truck mentioned in chapter 6.1.4]. Instead of the bucket a low-bed is connected to the truck. A rotary assembly is mounted on truck right above the back axe. On this assembly a heavy duty boom is mounted. The boom can be lifted and lowered with a big hydraulic cylinder. On this boom the low-bed is coupled.

The mine has two different types of low-beds one back loader and one front loader. The back loader is the Dresser 210M. This unit doesn't need to be decoupled whilst loading, but due to this design the low-bed is wide to fit bigger machinery and the payload is confined. The other low-bed is designed by TowHaul and the layout is a decoupled loading unit. This means that the low-bed has to be decoupled from the pulling truck, the CAT 793B, in order to load another machine. This pulling truck was formally used as normal haul-truck and was rebuilt now to be used with a low-bed.

Dresser 210M	
Engine:	982kW
Speed:	48,3km/h
Payload:	145,0t

P 53: Dresser 210M low-bed (#131-02) at maintenance

CAT 793B + TowHaul	
Engine:	1534kW
Speed:	54,0km/h
Payload:	249,5t

P 54: CAT 793B low-bed (#132-01) at Bruce stock pile

These machines are only used for transporting crawler machines from and to certain areas.

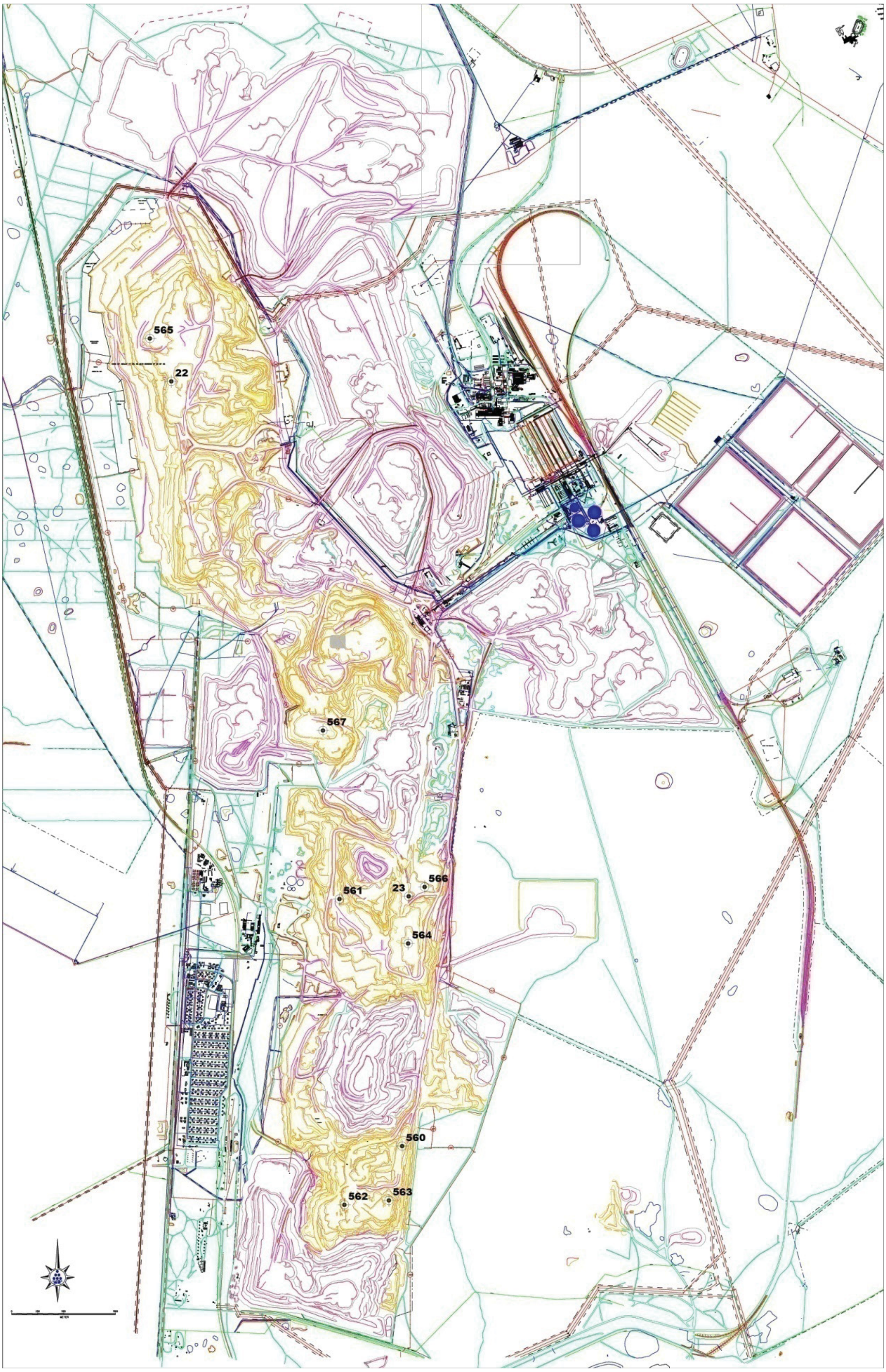
Problem:

The Dresser 210M need more attention in the point of maintenance, because this machine is quite old.

6.3] Shovels

The problems with the shovels are that they are moved weekly. So the position and all related distances are incorrect to the actual practise. The description is done according to a snapshot from the calendar week 29 (16.07.2007-20.07.2007).

As described in chapter 4 there are three primary shovels working in Vliegveld (#560, #562, #563), four in Dagbreek/ Watergat (#23, #561, #564, #566), one in GR35 (#567) and two in GR50 (#22, #565).



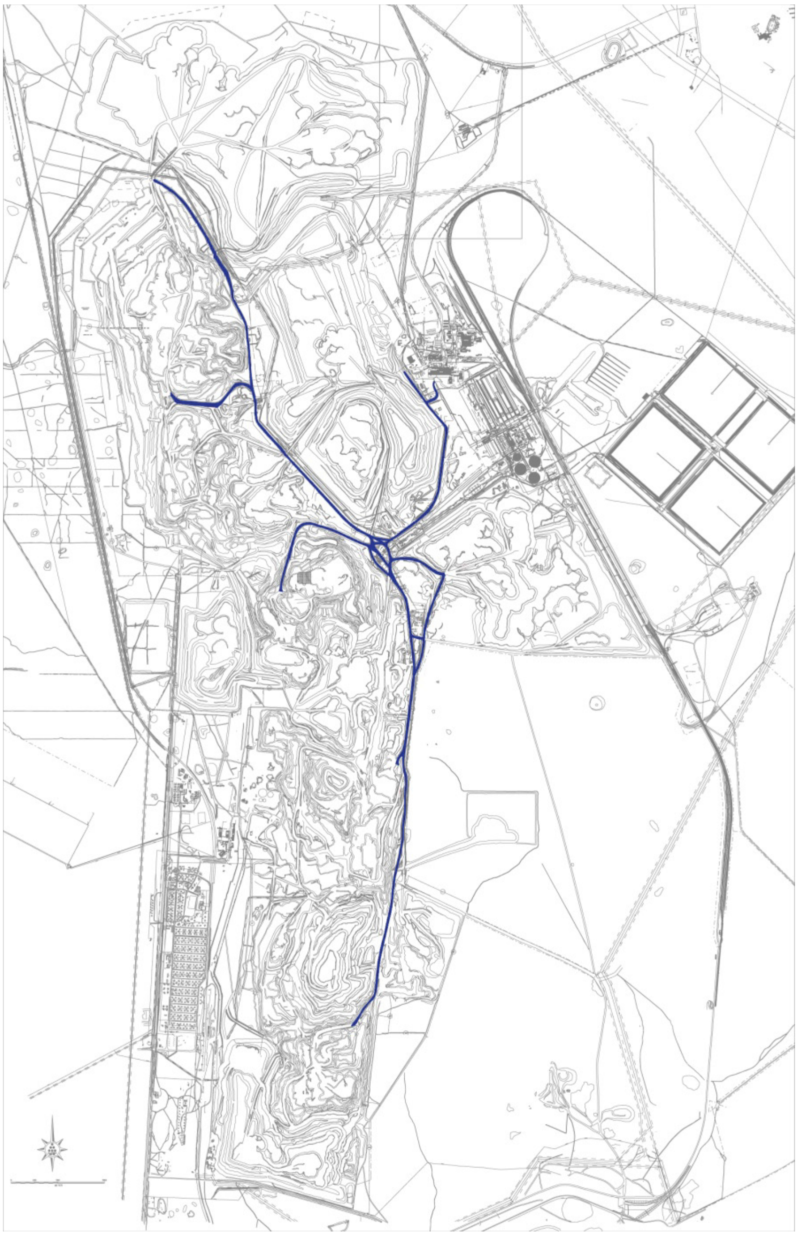
P 55: Position of primary shovels in calendar week 29

6.4] Roads

This section will give an overview, what types of roads are used, where they are and how long they are. The relevant roads for the calculation are the secondary ones, because they are maintained by secondary equipment. The primary roads are used by secondary machinery too, in order to drive from one pit area to another one.

The mines dispatch system is manufactured by Modular Mining Systems. Every block and every fixture like, crushers and stock piles are equipped with a call point. This points mark endpoints of roads. In a distance of a kilometre other call points are situated. These waypoints mark a route for instance from a crusher to a block. All call points are adjusted in x, y and z direction. So it is possible to estimate a specific distance and even a gradient for an incline or a decline.

6.4.1] Main roads



P 56: Main roads

The main roads in the pit lead from the offices to the primary crusher and from there to the North and the South. The main ramps down to GR35 and GR50 and the two ramps to the main stock pile Bruce are part of the main road system too. Pantograph lines are used on the incline from the different pits and up to Bruce to decrease the fuel consumption and increase the uphill speed of the primary haul trucks.

P 57: Lectra Haul (Unitrig) MK36 (#207) on pantograph line in GR35

P 58: Komatsu 730E (#519) on pantograph line in Vliegveld

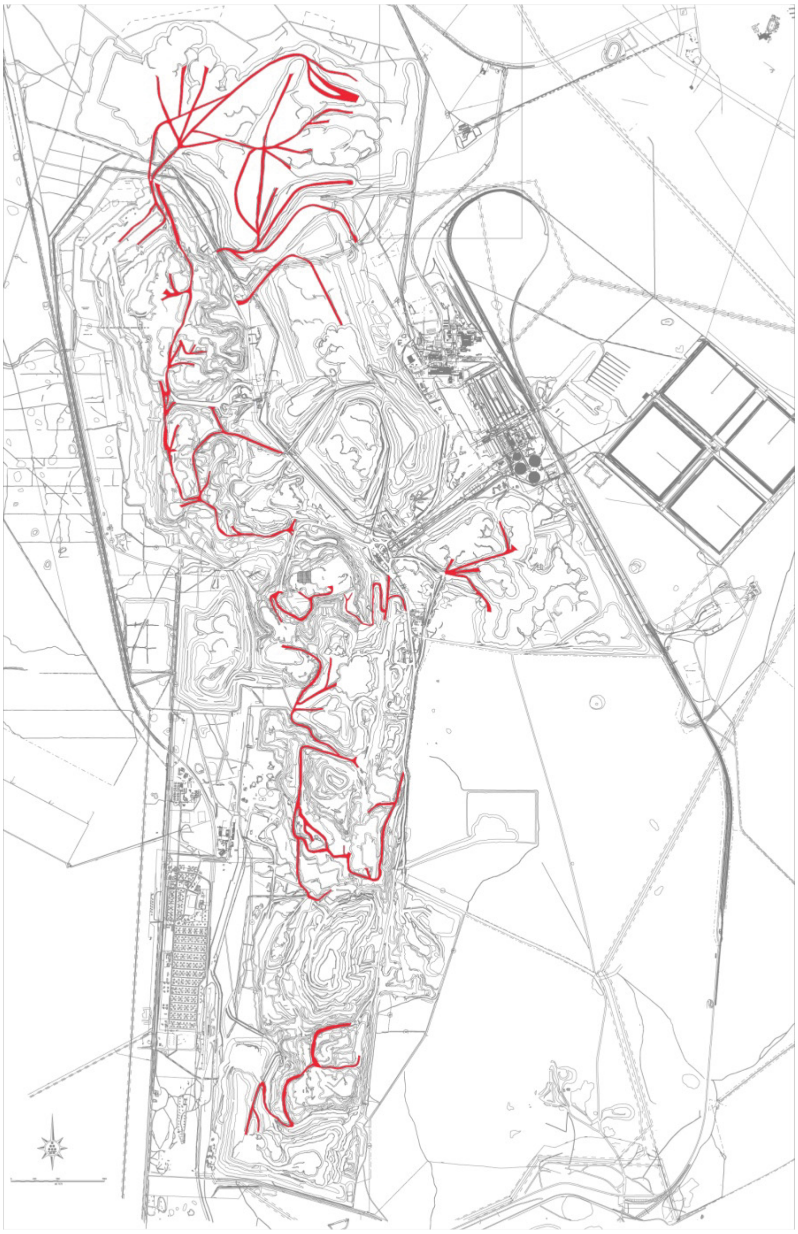
These roads are permanently used and because of that, the road is very wide, approximately three times a truck width, and equipped with road islands and a lot of safety applications, like traffic signs and reflectors.

P 59: Primary road leading to Vliegveld

Because of the importance of these roads it is maintained by a contractor named Dust-a-Side. These roads should not be sprayed with water, because the contractor uses a certain type of fluidised tar for them, to bind the dust on the ground. Regardless of this effort the problem of dust on these roads is still a serious one.

The approximate distance of primary roads is about 15,200m.

6.4.2] Secondary roads



P 60: Secondary roads

Secondary roads are those which lead the way to the different stock piles or the different loading zones. Most of the roads are only temporary, because they are normally built on mine able ore blocks. These roads are maintained by secondary equipment. They are being sprayed with water to reduce the amount of dust. The graders keep the roads clear of stones and uneven floors.

The approximate distance of secondary roads is about 16,900m.

6.4.3] Tertiary roads

Tertiary roads are only temporary ones which are used to access the different stock pile regions or different loading blocks. Those streets are, like the secondary roads, maintained by secondary equipment. They will be part of the calculation too, because they are used to calculate the road related distances between shovels, stock piles or secondary roads.

6.5] Stock piles / Waste dumps

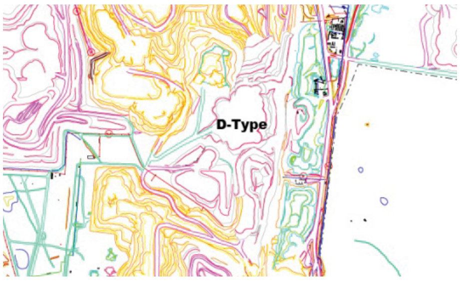
Stock piles are used to store different types of material in certain areas. The material stored there is either being reprocessed or dumped out of the pit. This section will describe the different sites, what type of material is stored and what it will be used for. The names of the different stock piles are comprised of the name of the stock pile and the material which is piled there. The description BruceC for example, means stock pile Bruce with material type C.

6.5.1] Vliegveld

P 61: Vliegveld stock pile

This is the most southern pile in the pit and marks the boundary of the pit as well. There is waste material B, C and D stored to backfill the Vliegveld pit. This stock pile is mainly used to pile waste material from the Vliegveld area.

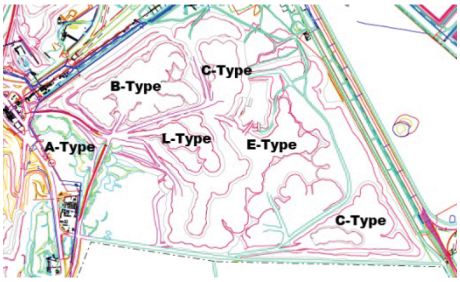
6.5.2] Sloep



P 62: Sloep stock pile

This stock pile is used to dump D material for refilling the Dagbreek/ Watergat pit as well as parts of the GR35 pit. The material at Sloep is dumped by the contractor Hitricon and is not used by Kumba at the moment. Hitricon is hauling waste material from Dagbreek/ Watergat pit and topsoil from the western and southern expansion of this pit to the Sloep stock pile.

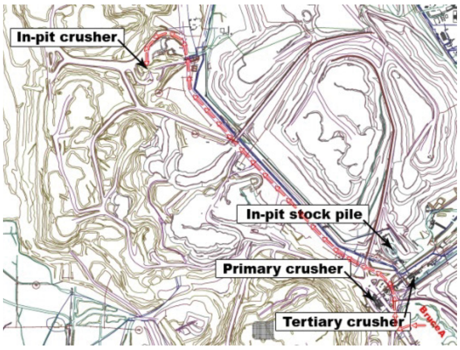
6.5.3] Bruce



P 63: Bruce stock pile

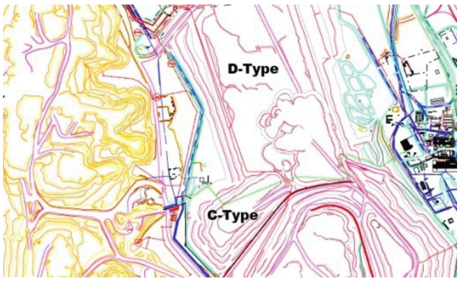
Bruce is the biggest and most important stock pile at Sishen Iron Ore Mine. Nearly all material types are piled at Bruce. Material A is transported from the southern pits to Bruce A for bridging shortages in the production of high grade ore. These shortages can be caused by breaking down of shovels or trucks, or the mine is processing waste material and can't produce the necessary amount of high grade ore for the plant. The material types B and L are special ones, because they will be processed in the new SEP plant. The piled C and E material is used for refilling GR35.

There is some additional information about BruceA. The contractor Tau-mining is loading material at BruceA and is hauling it to the primary and in-pit crusher. With the material crushed at the in-pit crusher, the in-pit stock pile is fed. This material is used for blending at the tertiary crusher, or to guarantee a constant material flow to the plant when shortages occur or the primary crusher is down.



P 64: Transport from BruceA to the in-pit crusher

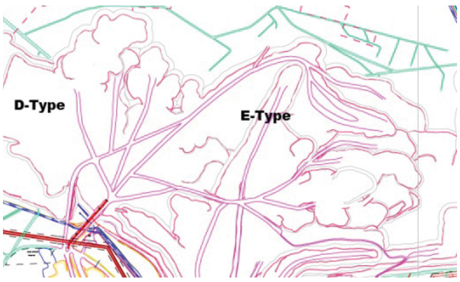
6.5.4] GR50



P 65: GR50 stock pile

This stock pile was used for dumping waste material C and D for GR50 pit. This material will be used for refilling GR50 pit again. Currently the stock pile is not in use.

6.5.5] GR80



P 66: GR80 stock pile

The GR80 stock pile is used to dump E and D material from the topsoil of the GR80 pit. The contractor Moolman Brothers is removing topsoil in the North to expand the GR80 pit and is dumping it at the GR80 stock pile. The stock pile is not used by Kumba at the moment.

7 Programming

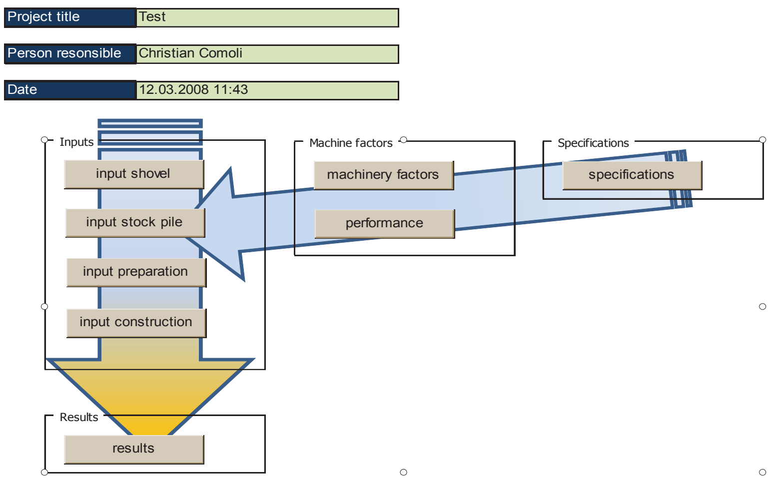
The programming will be calculating with efficient distances, loading and dumping cycles and will also incur different settings for the different material types.

The results of the calculation with the example data shown below are enclosed in appendix 9.5].

7.1] Start

The start page is the platform from where the whole program is controlled and maintained. Every worksheet, which is described in the following chapters, can be accessed from this sheet. The arrows on the page display the way of the program and mark the influence of the settings pages.

The start page also affords the entry of a project title and a responsible person. The date is created by the program.



F 1: Start Page

7.2] Input

As previously described it is important to separate the different operational areas for the calculation. Therefore the input is divided into three parts, the shovel input, the stock pile input and the construction input. From chapter 7.6] to chapter 7.11] it is described how the input is used to calculate the certain amount of the specific machinery.

7.2.1] Input shovel

The input for the shovels has to contain the shovel number and the material it is loading. In order claiming adjustability needs to allow the entry of more than one material type, because the shovels are loading different types of material. This is realised in the possibility to enter percentages of material the shovel will do. The total has to be 100%. It is pointed out by red or green if didn't reach or reached the target. It is not compulsory to enter the shortest road-related distance to the next shovel. This data will be set in settings in chapter 7.4.3]. In order to fulfil the duty to a global calculation model the possibilities are existing to enter own distances. As mentioned above the input only contains the P&H2300XPB and the Demag485 primary shovels. The other primary equipment has no need to be supported by secondary equipment.

input shovel number	input material							input distance
	A	B	C	D	E	L	Total	
560	25,0%	10,0%	35,0%	5,0%	20,0%	0,0%	95,0%	300 m
561	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	100,0%	
562	0,0%	30,0%	0,0%	30,0%	40,0%	0,0%	100,0%	200 m
563	30,0%	0,0%	30,0%	0,0%	0,0%	40,0%	100,0%	1200 m
600	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	600 m
565	20,0%	20,0%	20,0%	20,0%	20,0%	0,0%	100,0%	2000 m
566	40,0%	20,0%	15,0%	15,0%	10,0%	0,0%	100,0%	800 m
22	5,0%	55,0%	20,0%	0,0%	0,0%	20,0%	100,0%	
23	0,0%	50,0%	0,0%	0,0%	50,0%	0,0%	100,0%	
	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	

F 2: Input shovel

7.2.2] Input stock pile

The input for the stock pile demands the entry of the stock pile's name and the material which has to be dumped there. It is not required to put in the distances between the dump sides, because they won't change dramatically, but there is a possibility if it is necessary to do so.

input stock pile	input material	input distance
Vliegveld	B	
Bruce	A	3000 m
GR80	E	
Vliegveld	L	2000 m
Bruce	C	
GR80	D	

F 3: Input stock pile

7.2.3] Input preparation

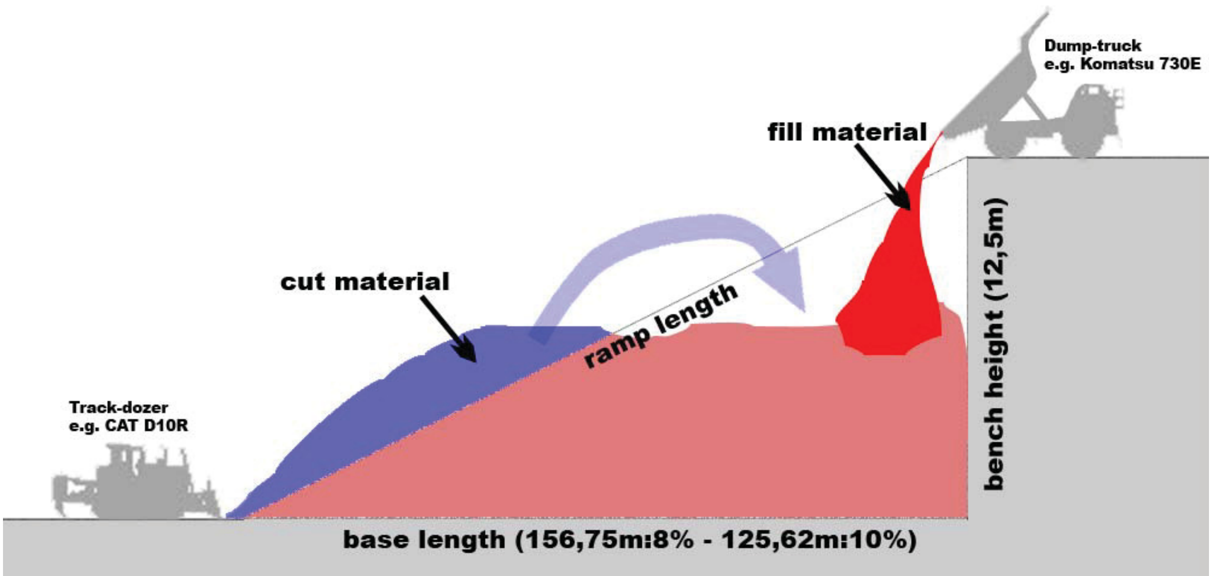
In order to calculate the time for preparation it is needed to know the volume of selective material and the block sizes.

selective volume		3000 m³
block	length	width
size	200 m	20 m

F 4: Input preparation

7.2.4] Input road construction

The construction of ramps is a very special operational area. The reason for this circumstance is that the main factors for the calculation are the machine performances. Therefore it is necessary to know what material, the amount of moved material, the angle of the ramp and the level span of the ramp. In order to predict the weekly production it is required to construct ramps as fast as possible, therefore it is essential to insert the days for construction. The moved material can either be cut or filled. This means that the material has to be pushed away or it has to be delivered by trucks.



P 67: Cut and fill material for road construction

The program only expects the entry of the material volume to be cut, the material to be filled is the whole ramp volume deducted by the cut material volume. The average inclination of ramps is 8% (4,57°), but sometimes 10% (5,71°) are used too. The level span is the amount of levels connected within the ramp.

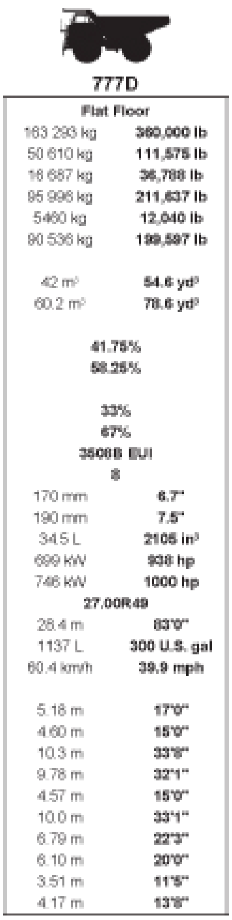
levels	3	-
angle	8	°
material to cut	120000,00	m³
material to fill	-119998,00	m³
days	5	-
material	D	-

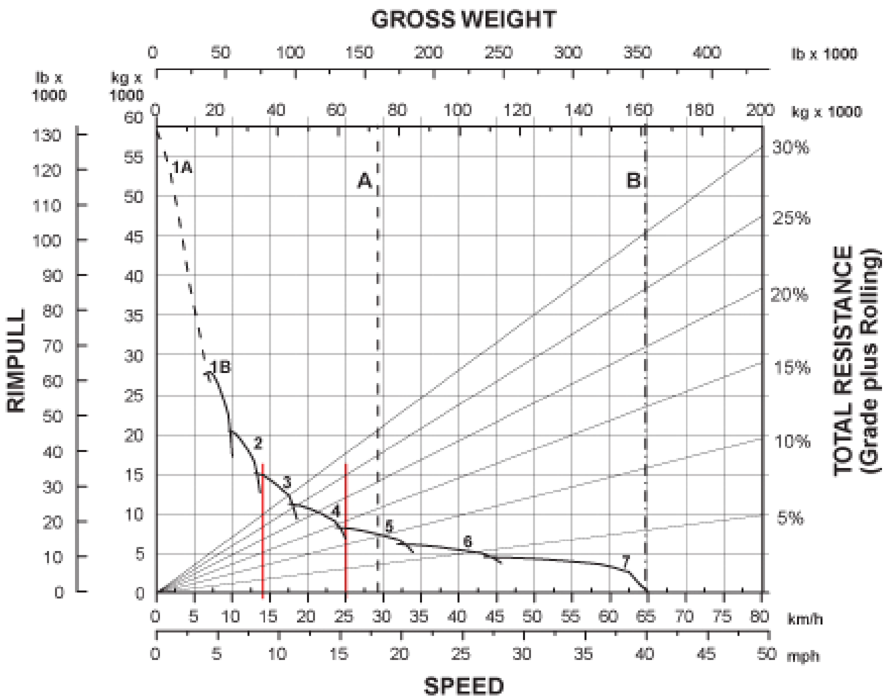
F 5: Input road construction

7.3] Performance

The program is designed to work with the machines' specific performances. These performances are kept in the unit [m^3/min]. This performance reflects the ability for a certain machine to handle a certain amount of material for a specific distance at a specific time. The formula and the tables are taken from Grundlagen der Erdbewegung (Eymer, Oppermann, Redlich, & Schümann, 2006).

The mines secondary machines are mainly Caterpillar and therefore the settings are done for those machines according to the caterpillar performance handbook. Those machines are CAT 824B, CAT D10R, CAT 16H, CAT 777D, CAT 990C. There are three additional performance charts which specify another operational field, constructions and the usage of a CAT 777D as a Water-truck.





P 68: CAT 777D specification (Caterpillar, 1998, 2007)

P 69: Rim-pull, Speed and grade-ability diagram for CAT 777D trucks (Caterpillar, 1998, 2007)

The description how the performance is calculated is done on one example, the performance data of the other machines is enclosed in appendix 9.3.1].

The example to describe the performance are the dump-trucks CAT 777C, D.

The performance of the CAT 777C is compare-able to the CAT 777D. Therefore the indicators of the CAT 777D are used.

CAT 777C, D	60,50	m³
speed forward	25,0	km/h 5 gear
speed backward	14,0	km/h 3 gear
filling level	90,00%	
manoeuvre	0,30	min
manoeuvre distance	30,00	m
loading time	0,60	min
floor condition	solid even	
loosening	40,00%	
material	0,80	-
time factor	0,67	-
floor condition	0,05	min
loading condition	0,05	min
full loading cycle	4,30	min
additional time	0,00	min
additional time	0,00	min

F 6: Performance data for a CAT777D dump-truck

The dump-trucks bucket capacity is 60,5m^3 heaped 2:1 according to SAE (Society of Automotive Engineers) guidelines. This capacity is multiplied with the filling factor of 90%. The result is 54,45m^3 of effective capacity.

The forward and backward speeds are used to determine the time needed for manoeuvre. This means forward and backward driving to position the truck underneath the front-end-loader bucket and at the dumping area. The speeds are taken out of the rim-pull- speed and grad-ability figure: P 69: Rim-pull, Speed and grade-ability diagram for CAT 777D trucks.

As distance for the manoeuvres the manoeuvre distance of 30m is used. The total time for the driving is 0,21min. The additional manoeuvre time of 0,30min is to add to the value of driving to get the total manoeuvre time of 0,51min. The value for the additional time is taken from the table below.

manoeuvre times	
good	0,15 min
medium	0,30 min
bad	0,50 min

F 7: Table of manoeuvre times

The actual hauling distances are being calculated out of the stock pile and shovel inputs and differ from area to area. They are viewed in the settings chapter at 7.4.3]. The time to drive the haulage distance is calculated with the average speed of 22,5km/h, taken from the machinery factors, mentioned in chapter 7.5]. As an example the distance to Vliegveld of 6.000m is used. The time to drive this distance is 16,0min. The truck has to drive back again so the time has to be doubled to 32,0min.

The loading time is used to calculate the total time consumption when being loaded by the CAT 990C. To calculate the time for the full loading cycle the effective bucket capacity of the trucks is divided by the effective bucket capacity of the front-end-loader. The bucket capacity of the CAT 990C is 8,4m^3 and the filling level is also 90%. This will determine the amount of loads to fill the truck. The amount of loadings can only be a total number and in this example it is 8. It has to be considered, that the front-end-loader is normally waiting with a filled bucket, so one of the loads will be weighted with 0,1min and the rest with the loading factor of 0,6. This determination results in a full loading cycle time of 4,3min. The full loading cycle time appears as an additional factor.

The floor condition as described is solid and even and results in a floor condition time factor of 0,05min as viewed in the table below.

floor condition	
very good	0,00 min
good	0,05 min
medium	0,10 min
difficult	0,15 min

F 8: Table of additional floor condition times

The loosening of the material during the handling increases the amount of material and leads to a decrease of the performance.

The material is a factor which describes the condition of the material. In this case it is a hard cut-able material and therefore the factor is 0,8, hard to push. It is a multiplication factor for the performance.

material	
loose	1,20 -
coarse	1,00 -
hard to cut	0,80 -
hard to push	0,80 -
ripped	0,70 -
blasted	0,60 -

F 9: Table of material factors

The time factor expresses the effective work time per hour. In this example 40 minutes per hour are used. This is a percentage of 67%. The factor of 40min is located in the settings worksheet and is mentioned in chapter 7.4.5].
The time factor loading condition of 0,05min is an additional factor which is shown in the table below.

loading/dipping conditions	
very good	0,00 min
good	0,05 min
diffcult	0,10 min

F 10: Table of additional loading and dipping condition times

Now all the data is complete to express the actual performance of a CAT 777D truck.

Now the effective capacity of 54,45m^3 is divided by the summarised minutes of 36,91min. This base performance of 1,48m^3/min is multiplied with the material factor of 0,8 and the material loosening of 40%. The value of the overall performance is

1,65m^3/min. For the effective performance the overall performance has to be multiplied with the time factor of 67%. In consequence the value of the effective performance is 1,10m^3/min.

CAT 777C, D	60,50	m³
speed forward	25,0	km/h 5 gear
speed backward	14,0	km/h 3 gear
filling level	90,00%	
manoeuvre	0,30	min
manoeuvre distance	30,00	m
loading time	0,60	min
floor condition	solid even	
loosening	40,00%	
material	0,80	-
time factor	0,67	-
floor condition	0,05	min
loading condition	0,05	min
full loading cycle	4,30	min
additional time	0,00	min
additional time	0,00	min

Machinery	average speed	bucket capacity
CAT 834B	15,00 km/h	7,75 m³
CAT D10R	7,00 km/h	22,00 m³
CAT 16H	12,00 km/h	4,88 m
CAT 777C, D WT	19,00 km/h	85,00 m³
CAT 777C, D	22,00 km/h	60,50 m³
CAT 990C	10,00 km/h	8,40 m³

distances	distances HMS
Vliegveld	6000 m
Dagbreek	3000 m
Sloep	1200 m
Bruce	300 m
GR35	2100 m
GR50	3300 m
GR80	4200 m

Calculation process	
effective capacity	
60,5*0,9=	
	54,45 m³
manoeuvre time	
30/(25*(1000/60))+30/(14*(1000/60))=	
	0,20 min
0,2+0,3=	
	0,50 min
hauling time	
2*(6000/(22*(1000/60)))=	
	32,73 min
loading cycle time	
ROUNDUP((60,5*0,9)/(8,4*0.9),0)=	
	8
(8-1)*0,6+0.1=	
	4,30 min
total time	
0,05+0,05+4,3+0,5+32,73=	
	37,63 min
base performance	
54,45/37,63=	
	1,45 m³/min
overall performance	
1,45*0,8*(1+0,4)=	
	1,62 m³/min
effective performance	
1,62*0,67=	
	1,08 m³/min

F 11: Performance calculation for a CAT777D

The other performance calculations are enclosed in chapter 9.3.2].

There is another additional time factor for cleaning machines, such as wheel- and track-dozers, displayed below.

cleaning conditions	
very good	0,05 min
good	0,10 min
diffcult	0,15 min

F 12: Table of additional cleaning condition times

The graders have an additional field for transactions which means how often they have to drive the same road-part to get the desired result.

7.4] Specifications

In order to make the program individually adaptable for future changes a series of settings have to take place.

7.4.1] Shovels

In order to calculate the available time between cleanings at the shovels the time for loading per truck, the number of cycles and the time for the truck change is needed. Due to the appearance of different loading machinery with different loading times it is a must to have a list which declares the shovel number to the shovel type and to the operational area to calculate the distances out of it. Out of this mentioned data the time between cleanings can be estimated. The time to clean the floor at the shovels is calculated with the machine performance and a material volume of 20% of a Komatsu 730E truck bucket capacity. The number of cycles is a subjective factor and declares the amount of loading cycles between cleanings. A shovel is loading a truck in three cycles. According to that, the time for truck change has to be included too.

loading times shovels	Demag485	P&H2300XPB
A	3,59 min	2,85 min
B	3,66 min	2,89 min
C	3,45 min	2,75 min
D	3,27 min	2,91 min
E	4,25 min	3,96 min
L	3,14 min	2,77 min

shovel	
cycles	6 -
truck change	1,8 min
loads per truck	3 -
clean time	6,32 min

730E bucket cap.	111 m³

shovel numbers	shovel types	area
22	Demag485	Dagbreek
23	Demag485	GR50
560	P&H2300XPB	Vliegveld
561	P&H2300XPB	Dagbreek
562	P&H2300XPB	Vliegveld
563	P&H2300XPB	Vliegveld
564	P&H2300XPB	Dagbreek
565	P&H2300XPB	GR50
566	P&H2300XPB	Dagbreek
567	P&H2300XPB	GR35

F 13: Shovel settings

7.4.2] Stock piles

The same thoughts can be made when calculating the time between cleanings at the stock piles. There is no need to specify the machinery and the operational area, because the main hauling machinery is the Komatsu 730E and the area is a necessary input for the stock piles. The old Lectra Haul (Unitrig) MK36 will be scrapped soon. Therefore it is not needful to consider them. The other tables on the right hand side below display the stock piles and the material which can be piled there. This table is needed to compare the entry in the input stock pile with the current practice. The track-dozer and the wheel-dozer are used to clean at stock piles, so the cleaning times for the wheel-dozer (wd) and the track-dozer (td) are calculated separately. The track-dozer is calculated in a way, that the machine is pushing the whole volume of a Komatsu 730E truck bucket over the edge. The wheel-dozer is only pushing 30% of the bucket capacity, because the machine is used at piles where trucks can dump over the edge. With those volumes and the machine performances, calculated according chapter 7.3], the time for cleaning can be determined. The only thing which is not exact is the time for truck change. This average number is spreading widely.

dumping times stock piles	Komatsu 730E
A	3,66 min
B	2,58 min
C	2,12 min
D	2,12 min
E	2,83 min
L	1,77 min

Bruce	GR50	GR80	Sloep	Vliegveld
A				
B				B
C	C			C
D	D	D	D	D
		E		
L				

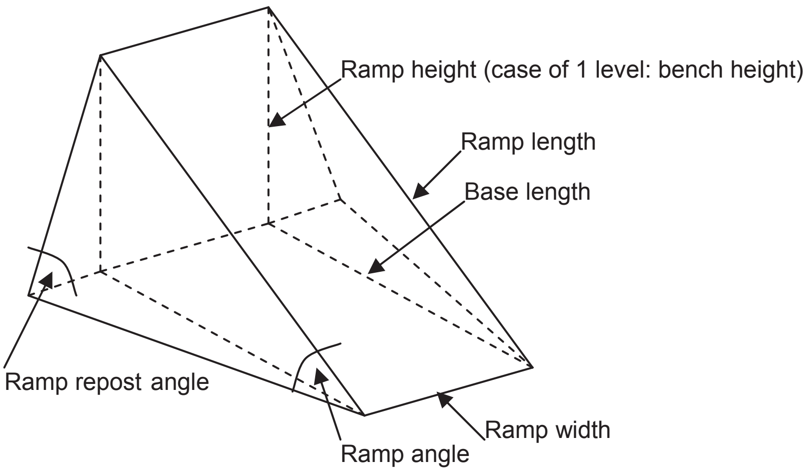
stock pile	
cycles	3 -
truck change	10,0 min
clean time wd	9,49 min
clean time td	8,74 min

730E bucket cap.	111 m³

F 14: Stock pile settings

7.4.3] Construction

For ramp construction the following tables are used. It is necessary to know the average bench height to determine the volume of the whole ramp. The ramp height is the bench height multiplied with the level span. To calculate the volume of the complete ramp, the ramp's width, which is three times the truck width and the ramp's length, which is depending on the inclination, have to be known. The numbers beneath the inclination are the base length.



P 70: Ramp specification

The natural material flow needs to be taken into consideration. It is specified with the ramp's repost angle. Out of the construction days entered the minutes are calculated to compare the ramp with the machine performances. The amount of push cut material and fill material indicate the percentage of the total volume which is not in place and has to be moved.

material factors	construction
A	
B	
C	1,9 -
D	1,7 -
E	1,5 -
L	

bench height	12,5 m

ramp length	8 %	10 %
	156,75 m	125,62 m
ramp volume	193745,75 m³	155273,57 m³

ramp repose angle	30 °
ramp width	22,62 m
ramp height	37,50 m
ramp length	470,25 m

construction time	7200 min

push cut	80,00%
push fill	30,00%

F 15: Construction settings

A list with material factors is used for the construction too. The only thing, which needs to be taken in consideration, is that the construction won't be done with high quality ore, so only C, D and E material is used for the construction projects. These factors express the difficulty of moving the material.

7.4.4] Distances

The following tables contain settings for road maintaining and driving.

The first table is the shovel matrix, which is used, when there is no entry at the shovel input. Due to the fact, that the shovels are spread around the whole mine and change their places quite often, the distances between them change too. According to input of the shovel numbers the distances between two certain machines can be determined.

shovel distances	22	23	560	561	562	563	564	565	566	567
22		5500 m	4500 m	500 m	4000 m	4200 m	800 m	6000 m	300 m	4000 m
23	5500 m		9000 m	7000 m	8500 m	8700 m	6000 m	500 m	5500 m	4500 m
560	4500 m	9000 m		6000 m	500 m	700 m	5000 m	9500 m	4500 m	8500 m
561	500 m	7000 m	6000 m		5500 m	5700 m	1000 m	7500 m	1700 m	2000 m
562	4000 m	8500 m	500 m	5500 m		200 m	4500 m	9000 m	4000 m	8000 m
563	4200 m	8700 m	700 m	5700 m	200 m		4700 m	9200 m	4200 m	8200 m
564	800 m	6000 m	5000 m	1000 m	4500 m	4700 m		6500 m	700 m	3000 m
565	6000 m	500 m	9500 m	7500 m	9000 m	9200 m	6500 m		6000 m	2500 m
566	300 m	5500 m	4500 m	1700 m	4000 m	4200 m	700 m	6000 m		5500 m
567	4000 m	4500 m	8500 m	2000 m	8000 m	8200 m	3000 m	2500 m	5500 m	

F 16: Shovel interacting distances matrix

In the fourth column the driving distances between the areas according to the row of the stock pile input are calculated.

distances	driving	distances total
Vliegveld	5600 m	5600 m
Dagbreek	4000 m	7000 m
Sloep	3000 m	3600 m
Bruce	3600 m	7300 m
GR35	4100 m	0 m
GR50	3200 m	0 m
GR80		

F 17: Driving distances

The following table is only a calculation table, which expresses the use of areas in order to calculate the distances only between used areas.

Vliegveld	1
Dagbreek	2
Sloep	3
Bruce	4
GR35	5
GR50	6
GR80	7

F 18: Area codes

As viewed the 5th line of the first column is missing, this is because the entry of shovel number in input shovel, check chapter 7.2.1], is incorrect.
The same occurs in column two, line four. This cell is blank according to a violation between the stock pile and the dumped material. The input data in input stock pile, viewed in chapter 7.2.2], has to be compared with the table in chapter 7.4.2] in order to see why this cell is blank.

The used areas columns pick every number occurring in the two left columns and display them once in an ordered way from 1 to 7. In the first column the numbers 3 and 5 are replaced by 0. This means that these areas are not used.

The top 0 in the right column is a reference number. The numbers below are the same as in the used area column only avoiding the ceros from the left column. This column is used to determine the total distances.

shovel area	stock pile area	used areas	0
1	1	1	1
2	4	2	2
1	7	0	4
1		4	5
	4	0	7
6	7	6	
2		7	
2			
6			
6			

F 19: Area calculation

7.4.5] Work time

In consideration of the mode of operation a working hour is not used in total, so it was necessary to determine the time of actual work per hour and calculate the work time per shift out of that. The actual work time per hour is used to estimate the time factor for the machine performances and the construction calculation. The factor is a ration between the total work time and the actual work time. The total work time is used to determine what could be achieved. It is used for the calculation of the water truck's season factors.

work time per hour	40 min	60 min
work time per shift	480 min	720 min

F 20: Work time per shift

7.4.6] Road maintenance

The pump rate is used for determination of water usage for spraying the roads with the water-trucks. The pump rate unit is m³/min and is specified for the pumps used on the water-trucks. The pumps manufactured on the trucks are KSB 100/400. With the tank volume of the water truck and the pump rate the emptying time is estimated. The refilling time is an average value and depends on the flow rate of the different filling stations. The spreading width, the pump rate and the truck's speed are needed to determine the water volume per square meter of road. The summer factor is calculated out of the total work time per shift divided by the emptying time plus the refilling time. The winter factor is calculated the same way, except, that 20 minutes are added to the value of the emptying time plus the refilling time. These 20 minutes represent a decreased volume of water needed during the winter month.

pump rate	2,67 m³/min
spread width	17,0 m
emptying time	31,84 min
refilling time	19,00 min
water volume	0,00050 m³/m²
summer	14,16 -
winter	10,16 -

F 21: Watering specifications

As there is no input for road maintaining the distances for cleaning and driving are fixed form and to every section of the mine.

distances	cleaning
Vliegveld	2000 m
Dagbreek	1200 m
Sloep	800 m
Bruce	600 m
GR35	1300 m
GR50	1000 m
GR80	500 m

F 22: Grading specifications

7.4.7] Road width

The road width is according to experience 3 times the truck width. As a safety issue the width from about 22m, which is three times the truck width, is set to 28m. The truck width is taken from the specifications in chapter 7.4.9].

road width	28,00 m

F 23: Road width

7.4.8] Preparation ratio

The preparation ratios are factors to express the amount of material of a block which needs to treat with secondary machinery.

The selective ratio is the ratio of selective material volume to be pushed by secondary machinery. The block as well as the loading area ratio expresses the ratio of the surface area at blast blocks and shovel loading areas to be prepared by secondary machinery. The trench spacing specifies the spacing between two ripping lines.

selective ratio	70%
block ration	60%
loading area ration	30%

trench spacing	1 m

F 24: preparation ratio

7.4.9] HMS

The following tables are all used to determine the amount of HMS needed at the different operational areas. How the HMS is calculated is explained in chapter 7.10].

The maximum shovel reach is used to calculate the ground area which has to be covert with HMS. The different loading machines have, due to their construction, a different maximum shovel reach. The truck specifications are also used to determine the area, which has to be covert with HMS.

The road proportion represents the part of the secondary roads in the areas which have to be treated with HMS.

The HMS thickness expresses the thickness of the HMS layer on top of the floor.

The material factors are subjective and shell express the difficulty of even out the floor. They are multiplication factors for the amount of HMS. The factors for the stock piles are higher, because the conditions are normally rougher than those of shovels. The loading areas have in general a higher priority than the stock piles. The machinery used for cleaning and pushing at stock piles is mainly a track-dozer. Due to the crawlers, the possible floor condition is worse than the floor condition created with rubber wheeled machinery such as the wheel-dozers or graders.

shovel reach	Demag485	P&H2300XPB
	18,34 m	18,64 m

730E turning cycle	28,00 m
730E width	7,54 m
730E length	12,83 m

road proportion	8%

HMS thickness	0,1 m

material factors	shovels	stock piles
A	2 -	2,4 -
B	1,75 -	2,2 -
C	1,5 -	1,8 -
D	1,25 -	1,4 -
E	1 -	1,2 -
L	1,8 -	2 -

F 25: Shovel, truck and material specifications for HMS

The distances HMS column displays the distances from Bruce to each section. This is because the current loading of HMS is done at Bruce stock pile and transported from there to the different sections.

distances	distances HMS
Vliegveld	6000 m
Dagbreek	3000 m
Sloep	1200 m
Bruce	300 m
GR35	2100 m
GR50	3300 m
GR80	4200 m

F 26: HMS hauling distances

7.5] Machinery factors

The worksheet machinery factors contains two tables, the machine specifications with average speed, availabilities and bucket sizes and the machine identification numbers.

7.5.1] Global machinery factors

This table displays the different machines with their typical specification and availability.

The availability and use of availability is used to determine the real amount of machinery needed out of the total amount.

The availability is always below 100%. It expresses the time the machine is available to work. The loss of effective useable time is caused by scheduled maintenance, which is: replacing of parts subjected to wear, oil change, tyre change, air filter cleaning, scheduled repairs and unscheduled maintenance, which is: unscheduled replacing of broken parts, closing leaks, any repairs caused either by accidents, misuse or part failure. The unscheduled maintenance should be kept as low as possible. It is even more suitable to increase the scheduled maintenance in order to avoid unscheduled maintenance, because the average time for unscheduled repairs is higher than those of scheduled repairs.

The use of availability, or utilisation, is like the availability normally below 100%. It should be as close to 100% as possible. The use of availability is the effective work time when the machine is available. For instance a machine is available 80% of the work time, these 80% availability are 100% utilisation. If the use of availability is now 70%, then the machine uses 70% out of the 80% for actual working and rest of 30% it is not working. The decreasing of effective work time is caused by the needs of the machine to refuel with diesel or water and unproductive time, like shift change, area changes, waiting.
The availability and the use of availability are increasing the needed machinery.

In order to express the availability and the use of availability the mine uses a GPS based vehicle tracking system from “VDO”. It is monitoring if the machine is switched off, if the ignition is on, if the engine is running and if the machine is moving. Out of the measured values the utilisation can be determined out of the availability.

The average speed is a subjective speed. It is a mean value of driving at a decline, an incline, on a straight road or a curve. The average speed is influenced by the overall weight, tyre pressure and the floor condition too. The data mentioned in the table is provided by the company “Record”. This company record and process data for the Sishen Mine.

The bucket capacities for the CAT 16H, the CAT 777D, the CAT 990C are taken from the CAT performance Handbook (Caterpillar, 1998, 2007). The capacities for the CAT 834B and the CAT D10R are calculated out of the data mentioned in the CAT performance Handbook (Caterpillar, 1998, 2007). The formula to calculate the blade capacity is V_B=0,8*w*h^2 and is taken from Grundlagen der Erdbewegung (Eymer, Oppermann, Redlich, & Schümann, 2006), where w and h are the width and the height of the blade and V_B the blade's capacity.

The lubricant usage of the machinery in the mine is recorded and processed by the company "Onfo". This company provided the fuel consumption for every machine group displayed in the table.

machinery	availibility	use of availibility	average speed	bucket capacity	fuel consumption
CAT 834B	88,90%	82,10%	15,00 km/h	7,75 m³	34,66 l/h
CAT D10R	86,10%	60,80%	7,00 km/h	22,00 m³	31,66 l/h
CAT 16H	74,00%	84,90%	12,00 km/h	4,88 m	12,93 l/h
CAT 777C, D WT	93,90%	74,00%	19,00 km/h	85,00 m³	43,30 l/h
CAT 777C, D	94,30%	83,40%	22,00 km/h	60,50 m³	39,60 l/h
CAT 990C	63,90%	70,60%	10,00 km/h	8,40 m³	42,79 l/h

F 27: Machine factors

7.5.2] Machine identification numbers

The identification number is unique for every machine. The same types of machines have normally numbers which are close together.
The layout of the numbers is Fxxx-Gxxxx.
F…functional group
G…Group number
For instance F022 G0006 is a grader CAT 16H. The F and the G is not displayed anymore, so the number is reduced to 022-06 to make it easier. This means this is the sixth machine from 22nd functional group.
The former number of the wheel-dozer CAT 834B would have been G024 F0322, but those machines are not sub-coordinated in functional groups anymore. Therefore the newer numbers only display three digits, like 322 which is the same wheel-dozer mentioned above.
The functional groups were created in order to calculate the costs for the machine group. With the introduction of IT, it was possible to calculate every machine separately. There is no need for functional groups anymore

A List of all machinery and their identification numbers is enclosed in appendix 9.2].

wheel-dozer	
CAT 834B	024-03
CAT 834B	316
CAT 834B	317
CAT 834B	318
CAT 834B	319
CAT 834B	320
CAT 834B	321
CAT 834B	322
CAT 834B	323
CAT 834B	324
Komatsu WD600-3	401
Komatsu WD600-3	402
Komatsu WD600-3	403

track-dozer	
CAT D10R	039-05
CAT D10R	303
CAT D10R	304
CAT D10R	305
CAT D10R	306
CAT D10R	307
CAT D10R	308
CAT D10R	309
CAT D10R	310
CAT D10R	311
CAT D10T	430
CAT D10T	431
CAT D10T	432
CAT D10T	433
CAT D10T	434

grader	
CAT 16H	022-06
CAT 16H	022-07
CAT 16H	240
CAT 16H	241
CAT 16H	242
CAT 16H	243

water-truck	
CAT 777D	222
CAT 777D	224
CAT 777D	225
CAT 777D	226
CAT 777C	231
CAT 777C	235

dump-truck	
CAT 777D	232
CAT 777D	233
CAT 777D	234
CAT 777D	236
Komatsu HD785-5	237
Komatsu HD785-5	238
Komatsu HD785-5	239

front-end-loader	
CAT 990C	134-01
CAT 990C	340
CAT 990C	341

F 28: Machine identification numbers

7.6] Wheel-dozers

As described in 6.2.1] the main tasks for wheel-dozers are cleaning at stock piles, waste dumps and loading areas. The determination of the amount of wheel-dozers is therefore divided in two parts.

7.6.1] Cleaning at shovels

The first part uses the shovel input. The shovel number is used to look up the type of the primary shovel and to return the time for the loading cycle per material type. The shovel needs three full cycles to load a truck completely. Due to the specifications in chapter 7.4.1] the wheel-dozer cleans after every second truck. Therefore the amount of cycles is 6. The number of cycles is multiplied with the sum of the cycle times multiplied with their ration, which have been entered in the shovel input, displayed in chapter 7.2.1]. An additional time for the truck change has to be added. This result is deducted with the previous calculated cleaning time at chapter 7.4.1].

The time mentioned in the first column is the time that can be used to drive to another primary shovel or half the waiting time. It is the time between two cleanings.
The second column uses the possible time from column one and deducts the time needed to drive the distance which was entered in the shovel input or in case it was not specified the distance according to the settings are used. To determine the time needed to drive the distance, the distance is divided by the speed. This speed is refers to the speed entered in the worksheet machine factors mentioned in chapter 7.5.1]. The output of the cell is the remaining time to drive to and clean at a third shovel.

Due to the amount of primary machinery it is not necessary for one wheel-dozer to serve more than three primary machines. If the time in the second column is still positive it is wrapped to the next row.

The third column now takes this time to calculate the time needed to drive to a third primary machine. If the time is wrapped a row down, the total of wheel-dozers is deducted by one. Is the cell value of the second or third column below zero, then the calculation refers to the first column again and starts the process from the beginning. In this case the total amount of wheel-dozers remains unchanged.

Every shovel can load every material, so there is no exception. If the material input is not 100% the program will display the error: Material. The second thing which will cause an error is the entry of a wrong shovel number. The program will react with the message: Shovel nr. .These errors are taking effect in the total amount of machines needed, because the faulty insertions are ignored.

Out of the total amount of wheel-dozers the list of machinery, according to their identification numbers mentioned in chapter 7.5.2], is determined.

wheel-dozer	250,00 m/min			9			
Material				-1	0		
6,47 min	-21,86 min			0	1	024-03	CAT 834B
7,71 min	0,59 min			0	2	316	CAT 834B
6,10 min	0,59 min	-16,14 min		-1	2	316	CAT 834B
Shovel nr.				-1	2		
6,95 min	-7,37 min			0	3	317	CAT 834B
6,63 min	-2,90 min			0	4	318	CAT 834B
8,27 min	-20,05 min			0	5	319	CAT 834B
9,60 min				0	6	320	CAT 834B
				0	7		
				6			

F 29: Wheel-dozer calculation

The calculation sheet is enclosed at appendix 9.4.1].

7.6.2] Cleaning at stock piles

The calculation for the stock piles is compare-able to the calculation of shovels.

The first column is calculating the time between the dumping of three trucks. This is the factor cycles in chapter 7.4.2]. Between the dumping of each truck the truck change time has to be added and the cleaning time to be deducted. The following structure is totally similar to the one the shovel is using.

The second column is calculating the distance to the next stock pile. It is displaying the remaining time to reach the next stock pile. With this time the possibility to reach a third stock pile is determined in the third column. It makes no sense to calculate more than three stock piles, due to the bad availability of the machines.

At this operational area the wheel-dozer is not used pushing A, B, C, D or L material, because it is too heavy to push it with a wheeled machine. If the material entry in the stock pile input is A, B or C the program will react with: No support. If the input for the area and the material type do not match with the specification table in chapter 7.4.2] an error: Material Type will occur. If the material type is not supported this information will occur before the error material type is displayed. The number of total wheel-dozers needed, will be reduced in both cases.

Out of the total amount of wheel-dozers at stock piles plus the total amount of wheel-dozers at shovels the list of machinery, according to their identification numbers mentioned in chapter 7.5.2], is determined.

wheel-dozer	250,00 m/min			12			
9,13 min	-22,01 min			0	7	321	CAT 834B
10,75 min	-10,74 min			0	8	322	CAT 834B
No support				-1	8		
Material type				-1	8		
8,44 min	-30,25 min			0	9	323	CAT 834B
8,44 min				0	10	324	CAT 834B
				0	11		
				0	12		
				0	13		
				0	14		
				10			

F 30: Wheel-dozer calculation

7.7] Track-dozers

The track-dozers main task, as described in 6.2.2], is cleaning or pushing at stock piles and waste dumps. The second task is building the roadbed at road and ramp constructions.

7.7.1] Pushing at stock piles

The track-dozer uses the same specifications as the wheel-dozer which is described in 7.4.2]. This machine is calculated completely similar to the wheel-dozer in chapter 7.6.2]. The only thing which is different is the machines specifications, which are shown in chapter 7.5.1], and the machine performance, which are shown in chapter 7.3].

The way of the calculation is completely the same. The first column determines the time left to go to another stockpile. This value is the time for the dumping of three trucks plus two times the truck change minus the cleaning time.
In the second column the available time to go to a third stock pile is determined. It is done in the same way as the wheel-dozer. The distance from one area to another is divided by the track-dozer's speed, calculated according to the entry in the machinery factor, described in chapter 7.5], and reduced with the value of the cleaning time.
There is no need to calculate more than three stock piles, because the stock piles are spread to widely to be reached with a wheel-dozer and there are normally two to four in use at the same time.

The message: No support is displayed for the one material type the wheel-dozer is not supporting. These material type is E. The error: Material type is also a valid error for the track-dozer. If the material type is not supported this information will occur before the error material type is displayed. Like the wheel-dozer the total amount of machinery needed will be reduced in both cases.

Out of the total amount of track-dozers the list of machinery, according to their identification numbers mentioned in chapter 7.5.2], is determined.

track-dozer	116,67 m/min			6			
No support				-1	0		
No support				-1	0		
9,51 min	0,03 min			0	1	039-05	CAT D10R
No support				-1	1		
No support				-1	1		
No support				-1	1		
				0	2		
				0	3		
				0	4		
				0	5		
				1			

F 31: Track-dozer calculation

7.7.2] Preparation of blocks

A major part of the tasks of track-dozers is to push selective material and preparation at blast blocks and shovel loading areas. The ratios for the amount of material treatment are specified in chapter 7.7.2].

Selective material treatment

In the first column the amount of selective material, as entered in preparation input in chapter 7.2.3], is multiplied with the selective ratio from chapter 7.4.8]. The amount of material is divided with the performance, the performance calculation is calculated according to the procedure explained in chapter 7.3], and displayed in column two. The time needed from column two is divided with the work time per shift, displayed in chapter 7.4.5], and displayed in column three. This value is totalised and indicates the amount of track-dozers.

Levelling on blast blocks

In the first column the block length is multiplied the block width, both entered in input preparation in chapter 7.2.3], and further multiplied with the blast block ratio, from chapter 7.4.8]. The value in column two is the value from column one divided with the performance, again calculated according to the procedure from 7.3]. The time needed for levelling is divided through the work time per shift, taken from chapter 7.4.5], and shows the totalised value of track-dozers needed in column three.

Levelling at loading areas

The value in the first column is the area at all the shovels calculated with a third of the shovel range circle plus two truck areas. The second column displays the value from the first column divided by the performance, calculated according to the method described in chapter 7.3]. The amount of track-dozers is displayed in column three and calculation out of the time needed calculated in column two divided by the work time per shift, the work time per shift is explained in chapter 7.4.5].

Out of the total amount of track-dozers for block preparation plus the total amount of track-dozers at stock piles the list of machinery, according to their identification numbers mentioned in chapter 7.5.2], is determined.

track-dozer	116,67 m/min			1						
2100,00 m³	313,74 min	1,00 -		1	2	303	CAT D10R			
2400,00 m²	232,50 min	1,00 -		1	3	304	CAT D10R			
2585,97 m²	250,52 min	1,00 -		1	4	305	CAT D10R			
				4						

7.7.3] Building the roadbed

The track-dozer is used in that case to push cut material in order to build the roadbed for a new road or ramp. Parts of the fill material needs to be pushed to. The ratios for the amount of material to be pushed are specified in the settings in chapter 7.4.3] construction.

In the first column first line the amount of cut material, which is an entry in input road construction in chapter 7.2.4], is multiplied with the specific material factor, which is explained in chapter 7.4.3]. The output of the calculation is weight with the pushing ration which is explained in chapter 7.4.3]. The result is divided by the machines performance, which is calculated according the procedure explained in chapter 7.3]. The performance data is a different one as the one used for pushing at stock piles in chapter 7.7.1]. Completely the same calculation steps are done with the fill material in the second row.
The time value for cut material is summed up with the time value of fill material and displayed in column two. This value expresses the time needed to push the entered amount of material.
The value in column three divides the needed time trough the time available. This result is further divided with a time value expressing the work time per shift, compare to chapter 7.12], and the result is the total amount of track-dozers needed to push the entered material during the specified time. The value has to be a total number so it is rounded up.

The entry of A, B or L material in the input road construction, shown in chapter 7.2.4], will lead to an error: Material type.

Out of the total amount of track-dozers for construction plus the total amount of track-dozers at stock piles and for block preparation the list of machinery, according to their identification numbers mentioned in chapter 7.5.2], is determined.

track-dozer	116,67 m/min			4						
16765,58 min	20629,30 min	4,00 -		4	5	306	CAT D10R	6	307	CAT D10R
3863,72 min				8	7	308	CAT D10R	8	309	CAT D10R

F 32: Track-dozer calculation

7.8] Graders

The grader is used for road maintaining and constructing. The special skills and the constructions are described in chapter 6.2.3].

7.8.1] Grading secondary roads

The first column's value is the cleaning distance according to the distances described in chapter 7.4.3] multiplied with the road width. The road width taken from the settings in the specifications worksheet mentioned in chapter 7.4.9].

This value is divided trough the grader's performance, which was calculated according to the scheme in chapter 7.3], in the second column. This value is divided by the number of transitions needed to clean the road. In this case it is one transition. The third column is comparing the value from column two with the work time shift, which was mentioned in chapter 7.4.5]. If the time is bigger than the work time per shift, than the time will be reduced with the value of the work time per shift and the amount of graders is increased. The fourth column calculates the time necessary to drive from one area to another. The total distances used are specified in chapter 7.4.3].

The second row first column is again calculation the road area for grading.

The second column is dividing the first column with the performance.

The third column now checks if the time from the first line third column plus the fourth column plus the second column second line is less than the work time per shift. Is this case true, then the amount of graders is reduced. Is this case false then the amount of graders is neither raised nor reduced. Is the time in column two bigger than the work time per shift, as described in line one, than the amount of graders is raised.

Out of the total amount of graders the list of machinery, according to their identification numbers mentioned in chapter 7.5.2], is determined.

grader	200,00 m/min			7						
56000,00 m²	372,37 min	372,37 min	28,00 min	0	1	022-06	CAT 16H			
33600,00 m²	228,93 min	228,93 min	35,00 min	0	2	022-07	CAT 16H			
0,00 m²	0,00 min	263,93 min	18,00 min	-1	2	022-07	CAT 16H			
16800,00 m²	121,35 min	403,28 min	36,50 min	-1	2	022-07	CAT 16H			
0,00 m²	0,00 min	439,78 min	0,00 min	-1	2	022-07	CAT 16H			
28000,00 m²	193,07 min	193,07 min	0,00 min	0	3	240	CAT 16H			
14000,00 m²	103,42 min	296,49 min		-1	3	240	CAT 16H			
				3						

F 33: Grader calculation

7.8.2] Finalising road constructions

For the calculation of road building the grading area is calculated out of the ramp length multiplied with the ramp width. This data is taken from the construction specifications shown in chapter 7.4.3]. This area is divided by the machine performance and shown in the first column. This performance is not the same as the one used in 7.8.1]. The calculation is done as in chapter 7.3] described with the grader construction settings enclosed in appendix 0. The amount of transitions is different too. It is three in the case of road building.
The value of the first column is divided by the available time and a time value, mentioned in chapter 7.4.5], and due to the fact that this number expresses the machines needed it has to be a total number and therefore it has to be rounded up.

Similar to the track-dozer the entry A, B for material type at the input road construction, mentioned in chapter 7.2.4], will lead to the error message: Material type.

Out of the total amount of graders for construction plus the total amount of graders for road maintenance the list of machinery, according to their identification numbers mentioned in chapter 7.5.2], is determined.

grader	200,00 m/min			3						
428,53 min		1,00 -		1	4	241	CAT 16H			
				4						

F 34: Grader calculation

7.9] Water-trucks

The water-truck is used according to the specifications in chapter 6.2.4] for road maintenance. To be more precise the machine is used to spray the secondary roads with water for dust suppression.

7.9.1] Watering secondary roads

The calculation uses water-truck's speed, road specifications and the pump rate to express the water volume needed. The cleaning distances, described in chapter 7.4.3], is multiplied with the road width, taken from chapter 7.4.7] and the water volume needed, from chapter 7.4.6]. The water-truck needs to spray the road more than once per shift and more often in summer than in winter. Therefore the calculations value is multiplied with a summer factor from October to March and with a winter factor from April to September. This value is displayed in the first column.

The volume from column one is divided by the performance, calculated according to the procedure described in chapter 7.3], and is further divided by the transitions in order to express the needed time for spraying. The water truck needs to be refilled after emptying the tank. A factor calculated out of the water volume needed divided by the water-truck's tank capacity and multiplied with the time to refill is added. This time is shown in column two.

The cleaning time is compared with the work time per shift in the third column. If this time is more than the work time per shift than the amount of water-trucks is raised. If this time is less than the work time per shift, the amount won't change.

The fourth column is calculating the time to drive from one area to another. The speed used to determine the time is taken from the machine specifications, described in the machinery factors in chapter 7.5].

The second row starts with the volume calculation in the first column and the necessary time calculation in column two. Are the time in column two plus the driving time in line one column four and the cleaning time in line one, column three less than the work time per shift, than the amount of water-trucks is reduced.

Out of the total amount of water-trucks the list of machinery, according to their identification numbers mentioned in chapter 7.5.2], is determined.

water-truck	316,67 m/min			7						
393,38 m³	180,49 min	180,49 min	17,68 min	0	1	222	CAT 777D			
236,03 m³	87,25 min	285,42 min	22,11 min	-1	1	222	CAT 777D			
0,00 m³	0,00 min	307,52 min	11,37 min	-1	1	222	CAT 777D			
118,01 m³	35,73 min	354,62 min	23,05 min	-1	1	222	CAT 777D			
0,00 m³	0,00 min	377,67 min	0,00 min	-1	1	222	CAT 777D			
196,69 m³	68,32 min	445,99 min	0,00 min	-1	1	222	CAT 777D			
98,35 m³	28,68 min	474,67 min		-1	1	222	CAT 777D			
1042,47 m³				1						

F 35: Water-truck calculation

7.10] Dump-trucks

The secondary dump-trucks are used for transporting HMS from Bruce to any destination in the mine. Further details to the truck's specifications are given in chapter 6.2.5].

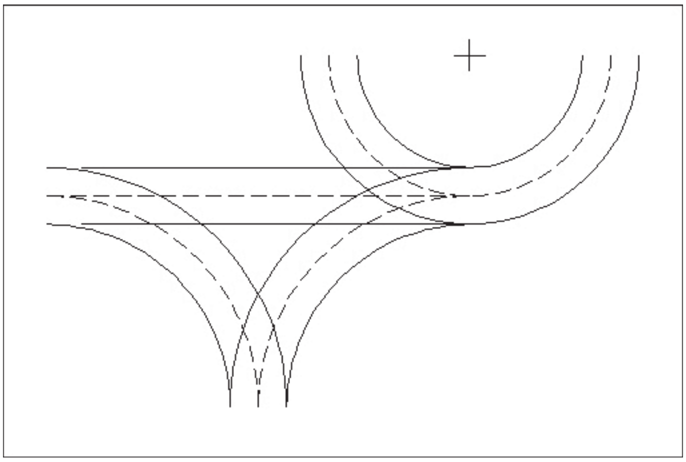
The amount of dump-trucks needed is depending on the amount of HMS needed. The amount of HMS is calculated using the settings described in chapter 7.4.9]. The amount of HMS differs between the different material types and areas where it is used at.

7.10.1] HMS volume calculation at shovels

Due to the appearance of different primary shovels the shovel's maximum reach is not constant. The volume calculation uses the shovel reach from the specifications in chapter 7.4.9] and adds a half truck width. The specifications for the trucks are also shown in chapter 7.4.9]. This is because the shovels have to load the truck's bucket in the centre. Halve of the truck which is not in the shovel reach still needs to have a ground support. The shovel reach and the half truck width are used as radiant to calculate a half circle area, because the shovels normally load the trucks one sided. To be able to load a truck properly it has to reverse park underneath the shovel bucket. Therefore the truck has to do a three point turn. The area the truck is using is a half circum cycle. To calculate this area the half of the truck's minimum turning cycle, which is the diameter taken from the outside of the truck, is reduced by the half truck width, in order to get the central line, and multiplied with the truck width. When the truck is leaving the loading area the machine uses a different way, which is expressed with three times the truck's length with multiplied with the truck's width. This area is multiplied with the material factor for shovels and the HMS thickness, also specified in chapter 7.4.9].

$$\left[\frac{\left(sr+\frac{tw}{2}\right)^2 * \pi}{2}+\frac{\left(\frac{tt}{2}+\frac{tw}{2}\right) * \pi}{2} * tw + 4 * \left(tl * tw\right)\right] * mf * ht$$

sr...$shovel-reach$
tw...$truck-width$
tt...$truck-turning-cycle$
mf...$materual-factor$
ht...$HMS-thickness$



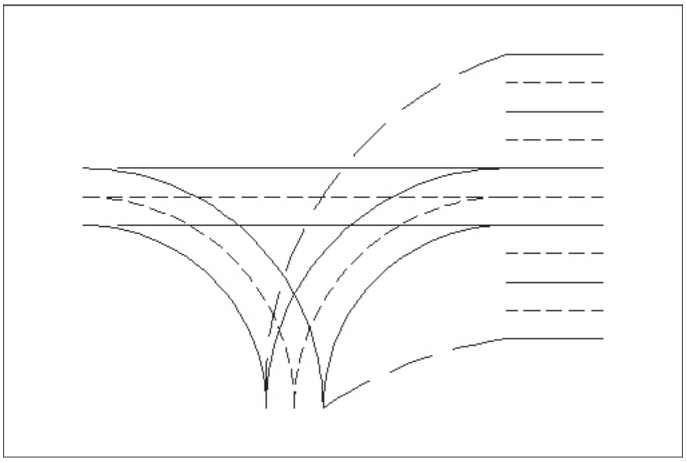
P 71: HMS area at shovels

7.10.2] HMS volume calculation at stock piles

The area at stock piles uses the same idea of truck manoeuvre as the calculation for shovels. To half circum cycle three times a truck's area is added. The spot where the trucks dump the material is not always the same. Therefore an area of the size of five trucks is added. The resulting area is again multiplied with the stock pile material factors and the HMS thickness. The specifications again are displayed in chapter 7.4.9].

$$\left[5 * (tw * tl) + \frac{\left(\frac{tt}{2} + \frac{tw}{2}\right) * \pi}{2} * tw + 4 * (tl * tw)\right] * mf * ht$$

tw...truck – width
tt...truck – turning – cycle
mf...materual – factor
ht...HMS – thickness



P 72: HMS area at stock piles

7.10.3] HMS volume calculation for secondary roads

The additional amount of HMS used for road maintenance is calculated with the cleaning distance, taken from the table shown in chapter 7.4.6], multiplied with the road width, viewed in chapter 7.4.7], the road proportion and the HMS thickness, both displayed in chapter 7.4.9].

7.10.4] Transport of HMS

In the first column the volume for the entered shovels, displayed at input shovel in chapter 7.2.1], plus the entered stock pile, which is shown in chapter 7.2.2], and the volume used for road maintenance are calculated. The calculation is done according to the volume determination in chapter 7.10.1], 7.10.2] and 7.10.3].

This volume is divided by the machines performance, calculated according to the steps explained in chapter 7.3], and displayed in column two.

The third column compares the calculated time from column two with the work time per shift. In the case that the resulting time is less than the work time per shift then the amount of dump-trucks is raised by one. In case the used time is higher than the work time per shift then the amount is raised by two.

The second line, first column calculates the amount of HMS again, according to the volume calculation in the chapter 7.10.1], 7.10.2] and 7.10.3].

The second column again divides the volume by the machine performance, determined with the procedure explained in 7.3].

The third column now takes the time from the first row, third column and adds the time from the second line, second column and compares it to the work time per shift. In case the time is less than the work time the amount of dump-trucks remains unchanged. If it is bigger the work time is deducted and the amount is raised by one.

Out of the total amount of dump-trucks the list of machinery, according to their identification numbers mentioned in chapter 7.5.2], is determined.

dump-truck	366,67 m/min			0						
864,56 m³	753,77 min	273,77 min		2	1	232	CAT 777D	2	233	CAT 777D
268,80 m³	176,65 min	450,42 min		0	2	233	CAT 777D			
0,00 m³	0,00 min	450,42 min		0	2	233	CAT 777D			
550,96 m³	332,52 min	332,52 min		1	3	234	CAT 777D			
0,00 m³	0,00 min	332,52 min		0	3	234	CAT 777D			
224,00 m³	123,17 min	455,69 min		0	3	234	CAT 777D			
369,87 m³	44,58 min	44,58 min		1	4	236	CAT 777D			
2278,19 m³				4						

F 36: Dump-truck calculation

7.11] Front-end-loader

The amount of front-end-loaders is directly depending on the dump-trucks and the amount of HMS to be loaded. The specifications for the front-end-loader are described in chapter 6.2.7].

7.11.1] Loading dump-trucks

The first column is the total amount HMS needed for all loading and dumping areas. The second column divides the volume by the machines performance, calculated according to the calculation steps mentioned in chapter 7.3].

Is the needed time in column two bigger than the work time per shift, than the work time will be deducted and displayed in column three.

Is the time in column three still bigger than the work time per shift, then the time will be deducted again and shown in column four. The total amount of front-end-loaders is the amount of used columns.

Out of the total amount of front-end-loaders the list of machinery, according to their identification numbers mentioned in chapter 7.5.2], is determined.

front-end-loader	166,67 m/min			0						
2278,19 m³	542,59 min	2,00 -		2	1	134-01	CAT 990C	2	340	
				2						

F 37: Front-end-loader calculation

7.12] Work time

Due to the calculation in minutes it is quite easy to calculate the work time. Only the wheel- and track-dozer are a bit complicated to determine, because the program has to look how many shovels, or stock piles are served, in order to recognise the time for driving from one operational area to the next. The time for driving plus the time for cleaning are weight with the amount of cycles possible per shift. All the other machinery is already weight with the work time per shift, mentioned in chapter 7.4.5], so the work time only has to be summed for each machine. The output is the actual work time per machine per shift. The work time is shown in the results, compare chapter 7.14], from page 7 onwards.

7.13] Fuel consumption

The fuel consumption for all machines is a function from the work time. The work time is multiplied with the fuel consumption per minute. The result is the actual fuel consumption per machine per shift. The fuel consumption is shown in the results, compare chapter 7.14], from page 7 onwards.

7.14] Results

The result pages are enclosed in appendix 9.5].

In order to separate the results, the pages are equipped with the project title, the responsible person and the date, which have been entered on the start page, described in chapter 7.1].

The first 6 pages display each machine group on one page. The page is sub coordinated in the specific operational areas and additional machines.

At the top of the box the amount of machinery is displayed and weight with the availability and the utilisation, both are mentioned in chapter 7.5.1].

Underneath the amount of machinery the operational area and the assigned machinery is shown. The machine numbers displayed are suggestions of the program, only the numbers not the amount can be changed in order to adapt it customary. It is possible that there is not enough machinery to accomplish the task in it's fully range. In that situation the program will display n.m.a. instead of the machine number. The term n.m.a. stands for no machine available.

For every machine group has to be a certain amount of additional machines, in order to replace broken machines. This chart is displayed underneath the operational areas.

Due to the possible appearance of information's and errors, the result page is displaying them as well. They are marked either with I for Information or E for error. An error can be terminated by reconsidering the inputs, because an invalid entry in the input sheets is directly leading to an error in the result pages.

From page 7 onwards the work time, fuel consumption and amount of material handling for each machine is displayed. Each machinery group is shown on one separate page.

The result page offers the possibility to save a copy in a separate file, named “secondary equipment-date.xls”, or to print it out. The date is the creation date of the results.

8 Conclusion

The output of the project is a decision tool that is able to calculate an exact amount of secondary machinery. Its input factors are primary machine setups, used stock piles and waste dumps.

The settings and parameter used within this program are specifically developed and determined for Sishen Iron Ore Mine circumstances. The machine manufacturer supplied the machine parameters. The machinery factors are ones which are total and not subjected by a distribution.
It was a general operation concern to use mine specific parameters, in order to improve accuracy.

It is a must for the production section follows the output parameters of the program. If these parameters adhered to the calculated data will be invalid for this operating condition. It will be hard to successfully implement this program, but it is a possibility to control the secondary machinery. Additional to the control on paper it will be necessary to physically control the machine operators if they fulfil their planed function.

The program developed and described above is satisfying the expectations for the test setup, particularly displayed in this project. The next stage will be an implementation in the operational system to test it under real conditions. It will have to proof that it is a universal tool for both long-term and short-term planning. A fully operational program will be the aim for the future.

If the program proved its reliability it could be implemented across the business unit of the Anglo American plc group.

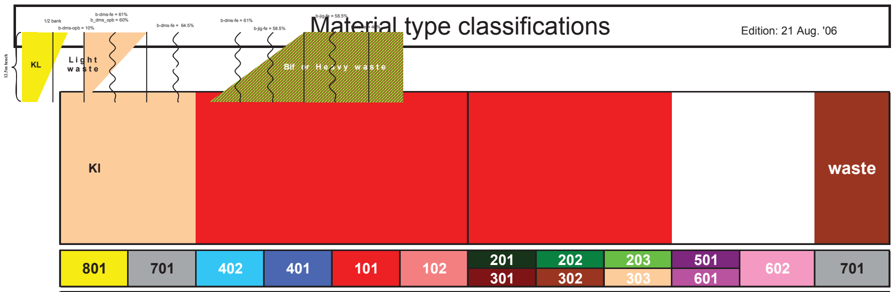
The results, displayed in chapter 9.5], has proven to be accurate. The production, planning and management section confirmed that the programs output results are displaying their expected results. The sections are convinced that this program will fulfil its duty and be an important part of the future mine-planning.

9 Appendix

9.1] Material types

Material type classifications

Edition: 21 Aug. '06



First condition in this order	Second condition in this order	Fe Grade or Yield Cut-off	CLASS	Production Geology & Grade Control description	stock pile	Min-ing	Maxi-miser
Full bench Ore		b_dms_fe >= 64.5	101	Full bench high grade ore (DMS plant)		A	A1
			102	Full bench ore with intermediate waste lenses (DMS plant)			A2
Less than full bench ore	High density BIF exclusively (RD >= 3.6)	b_dms_fe >= 61	201	Ore with high density Bif (DMS or JIG plant)	BIF	L	L1
		b_jig_fe >= 58.5	202	Ore with high density Bif (JIG plant)	BIF		
		b_ins_fe >= 40	203	Ore with high density Bif (JIG plant)	C	C	
	Low density waste including Clay (RD < 3.6)	b_dms_fe >= 61 & b_dms_opb >= 60	401	Ore with low density waste (JIG plant or selectif minning)	SP H4	A	A3
			402	Ore with low density waste (selective mining)	SP EKG		
	High density waste (RD >= 3.6)	b_dms_fe >= 61	301	Ore with high density waste (JIG or DMS plant)	SP EKG		A4
		b_jig_fe >= 58.5	302	Ore with high density waste (JIG plant)	B	B	B1
		b_ins_fe >= 40	303	Ore with high density waste (JIG plant)	C	C	
No ore	More than half bench Clay		801	Half bench or more of clay with or with out other waste	E	E	
	BIF (No more than 10% other waste)	b_jig_fe >= 58.5	501	Full bench high density Bif (JIG plant exclusively)	BIF	L	L2
	Remaining waste (RD >= 3.6) Excluding any possible kk kl lav law kwt mm dol di	b_jig_fe >= 58.5	601	Full bench high density waste (JIG plant exclusively)	B	B	B2
		b_ins_fe >= 40	602	Full bench high density waste (waste dump)	C	C	
	All sterile wastes		701	All sterile wastes	D	D	

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Compiled by Pierre Marais 03 Feb. '05

F 38: Specification chart for material types at Sishen Iron Ore Mine

9.2] Machine list

Number	Typ
Primary Equipment	
Trucks	
204	Lectra Haul (Unitrig) mk 36
207	Lectra Haul (Unitrig) mk 36
208	Lectra Haul (Unitrig) mk 36
209	Lectra Haul (Unitrig) mk 36
210	Lectra Haul (Unitrig) mk 36
211	Lectra Haul (Unitrig) mk 36
212	Lectra Haul (Unitrig) mk 36
213	Lectra Haul (Unitrig) mk 36
214	Lectra Haul (Unitrig) mk 36
215	Lectra Haul (Unitrig) mk 36
514	Komatsu (Haulpak) 730E
515	Komatsu (Haulpak) 730E
516	Komatsu (Haulpak) 730E
517	Komatsu (Haulpak) 730E
518	Komatsu (Haulpak) 730E
519	Komatsu (Haulpak) 730E
520	Komatsu (Haulpak) 730E
521	Komatsu (Haulpak) 730E
522	Komatsu (Haulpak) 730E
523	Komatsu (Haulpak) 730E
524	Komatsu (Haulpak) 730E
525	Komatsu (Haulpak) 730E
526	Komatsu (Haulpak) 730E
527	Komatsu (Haulpak) 730E
528	Komatsu (Haulpak) 730E
529	Komatsu (Haulpak) 730E
530	Komatsu (Haulpak) 730E
531	Komatsu (Haulpak) 730E
532	Komatsu (Haulpak) 730E
533	Komatsu (Haulpak) 730E
534	Komatsu (Haulpak) 730E
535	Komatsu (Haulpak) 730E
536	Komatsu (Haulpak) 730E
537	Komatsu (Haulpak) 730E
538	Komatsu (Haulpak) 730E
539	Komatsu (Haulpak) 730E
540	Komatsu (Haulpak) 730E
541	Komatsu (Haulpak) 730E
542	Komatsu (Haulpak) 730E
543	Komatsu (Haulpak) 730E
544	Komatsu (Haulpak) 730E
545	Komatsu (Haulpak) 730E
546	Komatsu (Haulpak) 730E
547	Komatsu (Haulpak) 730E
548	Komatsu (Haulpak) 730E
549	Komatsu (Haulpak) 730E
550	Komatsu (Haulpak) 730E
551	Komatsu (Haulpak) 730E
552	Komatsu (Haulpak) 730E
553	Komatsu (Haulpak) 730E
554	Komatsu (Haulpak) 730E

Number	Typ
Primary Equipment	
Rope-shovels	
560	P&H 2300 XPB
561	P&H 2300 XPB
562	P&H 2300 XPB
563	P&H 2300 XPB
564	P&H 2300 XPB
564	P&H 2300 XPB
566	P&H 2300 XPB
567	P&H 2300 XPB

Front-end-loaders	
570	Komatsu WA1200-3
571	Komatsu WA1200-3
572	Komatsu WA1200-3
580	Komatsu WA1200-3
582	CAT 994F
34	CAT 994C
35	CAT 994C
27	CAT 992G
339	CAT 992C
345	CAT 992G

Face-Shovel-excavator	
22	Demag 485
23	Demag 485
569	Demag 285

Backhoe-excavators	
572	Komatsu PC1250
573	Komatsu PC1100
574	Komatsu PC1100
578	Liebherr R984C Litronic

Legend	
(orange)	Out
(blue)	New

F 39: Primary machinery

Number	Typ
Secondary Equipment	
Wheel-dozer	
024-03	CAT 834B
316	CAT 834B
317	CAT 834B
318	CAT 834B
319	CAT 834B
320	CAT 834B
321	CAT 834B
322	CAT 834B
323	CAT 834B
324	CAT 834B
401	Komatsu WD600-3
402	Komatsu WD600-3
403	Komatsu WD600-3
Cabel-handler	
024-01	CAT 834B
024-06	CAT 834B
Track-dozer	
039-05	CAT D10R
303	CAT D10R
304	CAT D10R
305	CAT D10R
306	CAT D10R
307	CAT D10R
308	CAT D10R
309	CAT D10R
310	CAT D10R
311	CAT D10R
430	CAT D10T
432	CAT D10T
433	CAT D10T
434	CAT D10T
435	CAT D10T
436	CAT D10T
367	CAT D7R
467	CAT D7R
468	CAT D7R
Flat-bed	
132-03	Wabco 170D
131-02	Dresser 210M
062	CAT 793B
Fuel-trucks	
112-01	Dresser 210M
455-116	Mercedes Benz

Number	Typ
Secondary Equipment	
Graders	
240	CAT 16H
241	CAT 16H
242	CAT 16H
243	CAT 16H
022-06	CAT 16H
022-07	CAT 16H
372	CAT 24H
Water-trucks	
112-02	Dresser 210M
222	CAT 777D
224	CAT 777D
225	CAT 777D
226	CAT 777D
230	CAT 777D
231	CAT 777C
235	CAT 777C
Dump-trucks	
232	CAT 777D
233	CAT 777D
234	CAT 777D
236	CAT 777D
237	Komatsu HD785-5
238	Komatsu HD785-5
239	Komatsu HD785-5
Articulated dump-trucks	
162	CAT 730
163	CAT 730
Hydraulic-hammers	
357	CAT 375LME
371	CAT 375LME
373	CAT 385LME
Frontend-loaders	
134-01	CAT 990C
340	CAT 990C
341	CAT 990C
141	CAT IT14G
142	CAT IT14G
143	CAT IT14G
144	CAT IT14G

Legend	
(orange)	Out
(blue)	New
(green)	Dust-A-Side

F 40: Secondary machinery

9.3] Performance

9.3.1] Data

CAT 834B	7,75	m³
speed forward	11,3	km/h / 2gear
speed backward	14,0	km/h / 3gear
filling level	40,00%	
manoeuvre	0,50	min
cleaning distance	20,00	m
loosening	60,00%	
material	1,00	-
time factor	0,67	-
floor condition	0,15	min
cleaning condition	0,10	min
additional time	0,00	min
additional time	0,00	min
additional time	0,00	min

CAT D10R	22,00	m³
speed forward	5,3	km/h / 2gear
speed backward	8,9	km/h / 2gear
filling level	70,00%	
manoeuvre	0,50	min
pushing distance	40,00	m
loosening	40,00%	
material	1,20	-
time factor	0,67	-
floor condition	0,15	min
cleaning condition	0,10	min
additional time	0,00	min
additional time	0,00	min
additional time	0,00	min

CAT D10R Const.	22,00	m³
speed forward	4,0	km/h / 1gear
speed backward	8,9	km/h / 2gear
filling level	60,00%	
manoeuvre	0,15	min
pushing distance	20,00	m
loosening	20,00%	
material	1,00	-
time factor	0,67	-
floor condition	0,15	min
cleaning condition	0,15	min
floor compaction	0,20	min
additional time	0,00	min
additional time	0,00	min

CAT D10R Rip.		
speed forward	2,5	km/h / 1gear
speed backward	6,0	km/h / 2gear
filling level	60,00%	
manoeuvre	0,50	min
ripping distance	80,00	m
loosening	0,00%	
material	1,20	-
time factor	0,67	-
floor condition	0,15	min
cleaning condition	0,15	min
floor compaction	0,20	min
additional time	0,00	min
additional time	0,00	min

CAT 16H	4,88	m
speed forward	10,7	km/h / 4gear
speed backward	21,6	km/h / 6gear
overlap	60,00%	
manoeuvre	0,50	min
manoeuvre distance	20,00	m
loosening	0,00%	
material	0,80	-
time factor	0,67	-
transitions	1	-
floor condition	0,05	min
cleaning condition	0,05	min
additional factor	0,00	min
additional factor	0,00	min
additional factor	0,00	min

CAT 777C, D	60,50	m³
speed forward	25,0	km/h 5 gear
speed backward	14,0	km/h 3 gear
filling level	90,00%	
manoeuvre	0,30	min
manoeuvre distance	30,00	m
loading time	0,60	min
floor condition	solid even	
loosening	40,00%	
material	0,80	-
time factor	0,67	-
floor condition	0,05	min
loading condition	0,05	min
full loading cycle	4,30	min
additional time	0,00	min
additional time	0,00	min

CAT 16H Const.	4,88	m
speed forward	5,5	km/h / 2gear
speed backward	10,2	km/h / 4gear
overlap	60,00%	
manoeuvre	0,15	min
manoeuvre distance	20,00	m
loosening	0,00%	
material	1,00	-
time factor	0,67	-
transitions	4	-
floor condition	0,15	min
cleaning condition	0,10	min
additional time	0,00	min
additional time	0,00	min
additional time	0,00	min

CAT 777C, D WT	85,00	m³
speed forward	25,0	km/h 5 gear
speed backward	14,0	km/h 3 gear
filling level	100,00%	
manoeuvre	0,30	min
manoeuvre distance	30,00	m
floor condition	solid even	
loosening	0,00%	
material	1,0	-
time factor	0,67	-
transitions	3	-
floor condition	0,10	min
loading condition	0,10	min
additional time	0,00	min
additional time	0,00	min
additional time	0,00	min

CAT990C	8,40	m³
speed forward	7,2	km/h / 1gear
speed backward	14,2	km/h / 2gear
filling level	90,00%	
manoeuvre	0,50	min
loading distance	40,00	m
material loss height	60,00%	
floor condition	solid uneven	
dipping	CAT 777C, D	
loosening	20,00%	
material	0,8	-
time factor	0,67	-
floor condition	0,10	min
dipping condition	0,05	min
loading condition	0,00	min
additional time	0,00	min
additional time	0,00	min

F 41: Performance data of the other secondary machinery

9.3.2] Calculations

CAT 834B	7,75	m³
speed forward	11,3	km/h / 2gear
speed backward	14,0	km/h / 3gear
filling level	40,00%	
manoeuvre	0,50	min
cleaning distance	20,00	m
loosening	60,00%	
material	1,00	-
time factor	0,67	-
floor condition	0,15	min
cleaning condition	0,10	min
additional time	0,00	min
additional time	0,00	min
additional time	0,00	min

Machinery	average speed	bucket capacity
CAT 834B	15,00 km/h	7,75 m³
CAT D10R	7,00 km/h	22,00 m³
CAT 16H	12,00 km/h	4,88 m
CAT 777C, D WT	19,00 km/h	85,00 m³
CAT 777C, D	22,00 km/h	60,50 m³
CAT 990C	10,00 km/h	8,40 m³

Calculation process	
effective capacity	
7,75*0,4=	
	3,10 m³
manoeuvre time	
20/(11,3*(1000/60))+20/(14*(1000/60))=	
	0,19 min
0,19+0,5=	
	0,69 min
total time	
0,15+0,1+0,69=	
	0,94 min
base performance	
3,1/0,94=	
	3,29 m³/min
overall performance	
3,29*1*(1+0,6)=	
	5,27 m³/min
effective performance	
5,27*0,67=	
	3,51 m³/min

F 42: Wheel-dozer performance

CAT D10R	22,00	m³
speed forward	7,1	km/h / 2gear
speed backward	8,9	km/h / 2gear
filling level	70,00%	
manoeuvre	0,50	min
pushing distance	40,00	m
loosening	40,00%	
material	1,20	-
time factor	0,67	-
floor condition	0,15	min
cleaning condition	0,10	min
additional time	0,00	min
additional time	0,00	min
additional time	0,00	min

Machinery	average speed	bucket capacity
CAT 834B	15,00 km/h	7,75 m³
CAT D10R	7,00 km/h	22,00 m³
CAT 16H	12,00 km/h	4,88 m
CAT 777C, D WT	19,00 km/h	85,00 m³
CAT 777C, D	22,00 km/h	60,50 m³
CAT 990C	10,00 km/h	8,40 m³

Calculation process	
effective capacity	
22*0,7=	
	15,40 m³
manoeuvre time	
40/(7,1*(1000/60))+40/(8,9*(1000/60))=	
	0,61 min
0,61+0,5=	
	1,11 min
total time	
0,15+0,1+1,11=	
	1,36 min
base performance	
15,4/1,36=	
	11,34 m³/min
overall performance	
11,34*1,2*(1+0,4)=	
	19,06 m³/min
effective performance	
19,06*0,67=	
	12,70 m³/min

F 43: Track-dozer performance

CAT D10R Rip.		
speed forward	2,5	km/h / 1gear
speed backward	6,0	km/h / 2gear
filling level	60,00%	
manoeuvre	0,50	min
ripping distance	80,00	m
loosening	0,00%	
material	1,20	-
time factor	0,67	-
floor condition	0,15	min
cleaning condition	0,15	min
floor compaction	0,20	min
additional time	0,00	min
additional time	0,00	min

trench spacing	1 m

Calculation process

effective capacity

80*0,6*1=

48,00 m³

manoeuvre time

80/(2,5*(1000/60))+80/(6*(1000/60))=

2,72 min

2,72+0,5=

3,22 min

total time

0,15+0,15+3,22+0,2=

3,72 min

base performance

48/3,72=

12,90 m³/min

overall performance

12,9*1,2*(1+0)=

15,48 m³/min

effective performance

15,48*0,67=

10,32 m³/min

F 44: Track-dozer for preparation

CAT D10R Const.	22,00	m³
speed forward	4,0	km/h / 1gear
speed backward	8,9	km/h / 2gear
filling level	60,00%	
manoeuvre	0,15	min
pushing distance	20,00	m
loosening	20,00%	
material	1,00	-
time factor	0,67	-
floor condition	0,15	min
cleaning condition	0,15	min
floor compaction	0,20	min
additional time	0,00	min
additional time	0,00	min

Machinery	average speed	bucket capacity
CAT 834B	15,00 km/h	7,75 m³
CAT D10R	7,00 km/h	22,00 m³
CAT 16H	12,00 km/h	4,88 m
CAT 777C, D WT	19,00 km/h	85,00 m³
CAT 777C, D	22,00 km/h	60,50 m³
CAT 990C	10,00 km/h	8,40 m³

Calculation process

effective capacity

22*0,6=

13,20 m³

manoeuvre time

20/(4*(1000/60))+20/(8,9*(1000/60))=

0,43 min

0,43+0,15=

0,58 min

total time

0,15+0,15+0,2+0,58=

1,08 min

base performance

13,2/1,08=

12,17 m³/min

overall performance

12,17*1*(1+0,2)=

14,60 m³/min

effective performance

14,6*0,67=

9,73 m³/min

F 45: Track-dozer construction performance

CAT 16H	4,88	m
speed forward	10,7	km/h / 4gear
speed backward	21,6	km/h / 6gear
overlap	60,00%	
manoeuvre	0,50	min
manoeuvre distance	20,00	m
loosening	0,00%	
material	0,80	-
time factor	0,67	-
transitions	1	-
floor condition	0,05	min
cleaning condition	0,05	min
additional factor	0,00	min
additional factor	0,00	min
additional factor	0,00	min

Machinery	average speed	bucket capacity
CAT 834B	15,00 km/h	7,75 m³
CAT D10R	7,00 km/h	22,00 m³
CAT 16H	12,00 km/h	4,88 m
CAT 777C, D WT	19,00 km/h	85,00 m³
CAT 777C, D	22,00 km/h	60,50 m³
CAT 990C	10,00 km/h	8,40 m³

distances	cleaning
Vliegveld	2000 m
Dagbreek	1200 m
Sloep	800 m
Bruce	600 m
GR35	1300 m
GR50	1000 m
GR80	500 m

Calculation process

effective capacity

4,88*0,6*2000=

5856,00 m²

manoeuvre time

20/(10,7*(1000/60))+20/(21,6*(1000/60))=

0,17 min

0,17+0,5=

0,67 min

grading time

2*(2000/(12*(1000/60)))=

20,00 min

total time

0,05+0,05+0,67+20=

20,77 min

base performance

5856/20,77=

281,98 m²/min

overall performance

281,98*0,8*(1+0)=

225,58 m²/min

effective performance

(225,58*0,67)/1=

150,39 m²/min

F 46: Grader performance

CAT 16H Const.	4,88	m
speed forward	5,5	km/h / 2gear
speed backward	10,2	km/h / 4gear
overlap	60,00%	
manoeuvre	0,15	min
manoeuvre distance	20,00	m
loosening	0,00%	
material	1,00	-
time factor	0,67	-
transitions	4	-
floor condition	0,15	min
cleaning condition	0,10	min
additional time	0,00	min
additional time	0,00	min
additional time	0,00	min

Machinery	average speed	bucket capacity
CAT 834B	15,00 km/h	7,75 m³
CAT D10R	7,00 km/h	22,00 m³
CAT 16H	12,00 km/h	4,88 m
CAT 777C, D WT	19,00 km/h	85,00 m³
CAT 777C, D	22,00 km/h	60,50 m³
CAT 990C	10,00 km/h	8,40 m³

ramp repose angle	30 °
ramp width	22,62 m
ramp height	37,50 m
ramp length	470,25 m

Calculation process

effective capacity

4,88*0,6*470,25=

1376,88 m²

manoeuvre time

20/(5,5*(1000/60))+20/(10,2*(1000/60))=

0,34 min

0,34+0,15=

0,49 min

grading time

2*(470,25/(12*(1000/60)))=

4,70 min

total time

0,15+0,1+0,49+4,7=

5,44 min

base performance

1376,88/5,44=

253,18 m²/min

overall performance

253,18*1*(1+0)=

253,18 m²/min

effective performance

(253,18*0,67)/4=

42,20 m²/min

F 47: Grader construction performance

CAT 777C, D WT	85,00	m³
speed forward	25,0	km/h 5 gear
speed backward	14,0	km/h 3 gear
filling level	100,00%	
manoeuvre	0,30	min
manoeuvre distance	30,00	m
floor condition	solid even	
loosening	0,00%	
material	1,0	-
time factor	0,67	-
transactions	3,00	-
floor condition	0,10	min
loading condition	0,10	min
additional time	0,00	min
additional time	0,00	min
additional time	0,00	min

Machinery	average speed	bucket capacity
CAT 834B	15,00 km/h	7,75 m³
CAT D10R	7,00 km/h	22,00 m³
CAT 16H	12,00 km/h	4,88 m
CAT 777C, D WT	19,00 km/h	85,00 m³
CAT 777C, D	22,00 km/h	60,50 m³
CAT 990C	10,00 km/h	8,40 m³

distances	cleaning
Vliegveld	2000 m
Dagbreek	1200 m
Sloep	800 m
Bruce	600 m
GR35	1300 m
GR50	1000 m
GR80	500 m

Calculation process

effective capacity

4,88*0,6=

85,00 m³

manoeuvre time

20/(10,7*(1000/60))+20/(21,6*(1000/60))=

0,20 min

0+0,5=

0,50 min

hauling time

2*(0,8/(0,3*(1000/60)))=

12,63 min

total time

0,05+0+0+0,67+0,1=

13,33 min

base performance

0,6/0=

6,38 m³/min

overall performance

0*0,67*(1+0,8)=

6,38 m³/min

effective performance

(0*1)/0,05=

1,42 m³/min

F 48: Water-truck performance

CAT990C	8,40	m³
speed forward	7,2	km/h / 1gear
speed backward	14,2	km/h / 2gear
filling level	90,00%	
manoeuvre	0,50	min
loading distance	40,00	m
material loss height	60,00%	
floor condition	solid uneven	
dipping	CAT 777C, D	
loosening	20,00%	
material	0,8	-
time factor	0,67	-
floor condition	0,10	min
dipping condition	0,05	min
loading condition	0,00	min
additional time	0,00	min
additional time	0,00	min

Machinery	average speed	bucket capacity
CAT 834B	15,00 km/h	7,75 m³
CAT D10R	7,00 km/h	22,00 m³
CAT 16H	12,00 km/h	4,88 m
CAT 777C, D WT	19,00 km/h	85,00 m³
CAT 777C, D	22,00 km/h	60,50 m³
CAT 990C	10,00 km/h	8,40 m³

Calculation process

effective capacity

8,4*0,9=

7,56 m³

manoeuvre time

40/(7,2*(1000/60))+40/(14,2*(1000/60))=

0,50 min

0,5+0,5=

1,00 min

total time

0,1+0,05+0+1=

1,15 min

base performance

7,56/1,15=

6,56 m³/min

overall performance

6,56*0,8*(1+0,2)=

6,30 m³/min

effective performance

6,3*0,67=

4,20 m³/min

F 49: Front-end-loader performance

9.4] Calculations

9.4.1] Wheel-dozers at shovels

Input shovel number	Input Material	Input Distance
560	0	300 m
561	D	0
562	E	200 m
563	A	1200 m
600	B	600 m
565	D	2000 m
566	A	800 m
22	D	0
23	L	0
0	0	

shovel numbers	shovel types	area
22	Demag485	Dagbreek
23	Demag485	GR50
560	P&H2300XPB	Vliegveld
561	P&H2300XPB	Dagbreek
562	P&H2300XPB	Vliegveld
563	P&H2300XPB	Vliegveld
564	P&H2300XPB	Dagbreek
565	P&H2300XPB	GR50
566	P&H2300XPB	Dagbreek
567	P&H2300XPB	GR35

load times shovels	Demag485	P&H2300XPB
A	3,59 min	2,85 min
B	3,66 min	2,89 min
C	3,45 min	2,75 min
D	3,27 min	2,91 min
E	4,25 min	3,96 min
L	3,14 min	2,77 min

shovel	
cycles	6 -
truck change	1,8 min
loads per truck	3 -
clean time	6,32 min

machinery	average speed
CAT 834B	15,00 km/h
CAT D10R	7,00 km/h
CAT 16H	12,00 km/h
CAT 777C, D WT	19,00 km/h
CAT 777C, D	22,00 km/h
CAT 990C	10,00 km/h

shovel distances	22	23	560	561	562	563	564	565	566	567
22		5500 m	4500 m	500 m	4000 m	4200 m	800 m	6000 m	300 m	4000 m
23	5500 m		9000 m	7000 m	8500 m	8700 m	6000 m	500 m	5500 m	4500 m
560	4500 m	9000 m		6000 m	500 m	700 m	5000 m	9500 m	4500 m	8500 m
561	500 m	7000 m	6000 m		5500 m	5700 m	1000 m	7500 m	1700 m	2000 m
562	4000 m	8500 m	500 m	5500 m		200 m	4500 m	9000 m	4000 m	8000 m
563	4200 m	8700 m	700 m	5700 m	200 m		4700 m	9200 m	4200 m	8200 m
564	800 m	6000 m	5000 m	1000 m	4500 m	4700 m		6500 m	700 m	3000 m
565	6000 m	500 m	9500 m	7500 m	9000 m	9200 m	6500 m		6000 m	2500 m
566	300 m	5500 m	4500 m	1700 m	4000 m	4200 m	700 m	6000 m		5500 m
567	4000 m	4500 m	8500 m	2000 m	8000 m	8200 m	3000 m	2500 m	5500 m	

Line 1/Column 1		
Check for shovel, shovel type, material type and determine the loading time		
No material entered		Error: Material
Half time between cleanings		
=		
		0,00 min
Line 1/Column 2		
Check if second shovel is in reach		
=		
Empty because of error		
Line 1/Column 3		
Check if third shovel is in reach		
=		
Empty because of error		
Amount of wheel-dozers		
		0

Line 2/Column 1		
Check for shovel, shovel type, material type and determine the loading time		
		2,91 min
Half time between cleanings		
(6*2,91+((6/3)-1)*1,8-6,32)/2=		
		6,47 min
Line 2/Column 2		
Check if second shovel is in reach		
6,47-5500/(15*(1000/60))-6,32=		
No distance specified, therefore table: 5.500m		-21,8555551 min
Line 2/Column 3		
Check if third shovel is in reach		
=		
Zero because not reachable		0,00 min
Amount of wheel-dozers		
024-03-CAT834B		1

Line 3/Column 1		
Check for shovel, shovel type, material type and determine the loading time		
		3,96 min
Half time between cleanings		
(6*3,96+((6/3)-1)*1,8-6,32)/2=		
		9,62 min
Line 3/Column 2		
Check if second shovel is in reach		
9,62-200/(15*(1000/60))-6,32=		
		2,49444489 min
Line 3/Column 3		
Check if third shovel is in reach		
=		
Zero because not reachable		0,00 min
Amount of wheel-dozers		
316-CAT834B		2

Line 4/Column 1		
Check for shovel, shovel type, material type and determine the loading time		
		2,85 min
Half time between cleanings		
(6*2,85+((6/3)-1)*1,8-6,32)/2=		
		6,29 min
Line 4/Column 2		
Check if second shovel is in reach		
2,49=		
		2,49444489 min
Line 4/Column 3		
Check if third shovel is in reach		
2,49-200/(15*(1000/60))-2*1200/(15*(1000/60))-6,32=		
		-14,23 min
Amount of wheel-dozers		
316-CAT834B		2

Line 5/Column 1		
Check for shovel, shovel type, material type and determine the loading time		
Wrong shovel number entered		Error: Shovel nr.
Half time between cleanings		
=		
		0,00 min
Line 5/Column 2		
Check if second shovel is in reach		
=		
Empty because of error		
Line 5/Column 3		
Check if third shovel is in reach		
=		
Empty because of error		
Amount of wheel-dozers		
		2

Line 6/Column 1		
Check for shovel, shovel type, material type and determine the loading time		
		2,91 min
Half time between cleanings		
(6*2,91+((6/3)-1)*1,8-6,32)/2=		
		6,47 min
Line 6/Column 2		
Check if second shovel is in reach		
6,47-2000/(15*(1000/60))-6,32=		
		-7,85555511 min
Line 6/Column 3		
Check if third shovel is in reach		
=		
Zero because not reachable		0,00 min
Amount of wheel-dozers		
317-CAT834B		3

Line 7/Column 1		
Check for shovel, shovel type, material type and determine the loading time		
		2,85 min
Half time between cleanings		
(6*2,85+((6/3)-1)*1,8-6,32)/2=		
		6,29 min
Line 7/Column 2		
Check if second shovel is in reach		
6,29-800/(15*(1000/60))-6,32=		
		-3,23555511 min
Line 7/Column 3		
Check if third shovel is in reach		
=		
Zero because not reachable		0,00 min
Amount of wheel-dozers		
318-CAT834B		4

Line 8/Column 1		
Check for shovel, shovel type, material type and determine the loading time		
		3,27 min
Half time between cleanings		
(6*3,27+((6/3)-1)*1,8-6,32)/2=		
		7,55 min
Line 8/Column 2		
Check if second shovel is in reach		
7,55-5500/(15*(1000/60))-6,32=		
		-20,7755551 min
Line 8/Column 3		
Check if third shovel is in reach		
=		
Zero because not reachable		0,00 min
Amount of wheel-dozers		
319-CAT834B		5

Line 9/Column 1		
Check for shovel, shovel type, material type and determine the loading time		
		3,14 min
Half time between cleanings		
(6*3,14+((6/3)-1)*1,8-6,32)/2=		
		7,16 min
Line 9/Column 2		
Check if second shovel is in reach		
=		
Empty because no more shovels		
Line 8/Column 3		
Check if third shovel is in reach		
=		
Zero because not reachable		0,00 min
Amount of wheel-dozers		
320-CAT834B		6

Line 10/Column 1		
Check for shovel, shovel type, material type and determine the loading time		
Empty because no more entry		
Half time between cleanings		
=		
		0,00 min
Line 10/Column 2		
Check if second shovel is in reach		
=		
Empty because no more shovels		
Line 10/Column 3		
Check if third shovel is in reach		
=		
Zero because not reachable		0,00 min
Amount of wheel-dozers		
		6

F 50: Wheel-dozer shovel calculation

9.4.2] Wheel-dozers at stock piles

Input stock pile	Input Material	Input Distance
Vliegveld	B	0
Bruce	A	3000 m
GR50	E	0
Sloep	D	2000 m
Bruce	C	0
GR50	D	0
0	0	0
0	0	0
0	0	0
0	0	

dump times stock piles	Komatsu 730E
A	3,66 min
B	2,58 min
C	2,12 min
D	2,12 min
E	2,83 min
L	1,77 min

Bruce	GR50	GR80	Sloep	Vliegveld
A	0	0	0	0
B	0	0	0	B
C	C	0	0	C
D	D	D	D	D
0	0	E	0	0
L	0	0	0	0

stock pile	
cycles	3 -
truck change	10,0 min
clean time wd	9,49 min
clean time td	8,74 min

machinery	average speed
CAT 834B	15,00 km/h
CAT D10R	7,00 km/h
CAT 16H	12,00 km/h
CAT 777C, D WT	19,00 km/h
CAT 777C, D	22,00 km/h
CAT 990C	10,00 km/h

Line 1/Column 1	
Check for stock pile, material type and determine the loading time	
Wheel-dozer is used for D and E material	Information: No Support
Half time between cleanings	
=	
	0,00 min
Line 1/Column 2	
Check if second stock pile is in reach	
=	
Empty because of no support	
Line 1/Column 3	
Check if third stock pile is in reach	
=	
Empty because of no support	
Amount of wheel-dozers	
	0

Line 2/Column 2	
Check for stock pile, material type and determine the loading time	
Wheel-dozer is used for D and E material	Information: No Support
Half time between cleanings	
=	
	0,00 min
Line 2/Column 2	
Check if second stock pile is in reach	
=	
Empty because of no support	
Line 2/Column 3	
Check if third stock pile is in reach	
=	
Empty because of no support	
Amount of wheel-dozers	
	0

Line 3/Column 1	
Check for stock pile, material type and determine the loading time	
Wrong material entered	Error: Material type
Half time between cleanings	
=	
	0,00 min
Line 3/Column 2	
Check if second stock pile is in reach	
=	
Empty because of error	
Line 3/Column 3	
Check if third stock pile is in reach	
=	
Empty because of error	
Amount of wheel-dozers	
	0

Line 4/Column 1	
Check for stock pile, material type and determine the loading time	
	2,12 min
Half time between cleanings	
(3*2,12+(3-1)*10-9,49)/2=	
	8,44 min
Line 4/Column 2	
Check if second stock pile is in reach	
8,44-2000/(15*(1000/60))-9,49=	
	-9,04833267 min
Line 4/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of wheel-dozers	
321-CAT834B	7

Line 5/Column 1	
Check for stock pile, material type and determine the loading time	
Wheel-dozer is used for D and E material	Information: No Support
Half time between cleanings	
=	
	0,00 min
Line 5/Column 2	
Check if second stock pile is in reach	
=	
Empty because of no support	
Line 5/Column 3	
Check if third stock pile is in reach	
=	
Empty because of no support	
Amount of wheel-dozers	
	7

Line 6/Column 1	
Check for stock pile, material type and determine the loading time	
	2,12 min
Half time between cleanings	
(3*2,12+(3-1)*10-9,49)/2=	
	8,44 min
Line 6/Column 2	
Check if second stock pile is in reach	
=	
No more stock piles	
Line 6/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	
Amount of wheel-dozers	
322-CAT834B	8

Line 7/Column 1	
Check for stock pile, stock pile type, material type and determine the loading time	
Empty because no more entry	
Half time between cleanings	
=	
	0,00 min
Line 7/Column 2	
Check if second stock pile is in reach	
=	
Empty because no more stock piles	
Line 7/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of wheel-dozers	
	8

Line 8/Column 1	
Check for stock pile, stock pile type, material type and determine the loading time	
Empty because no more entry	
Half time between cleanings	
=	
	0,00 min
Line 8/Column 2	
Check if second stock pile is in reach	
=	
Empty because no more stock piles	
Line 8/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of wheel-dozers	
	8

Line 9/Column 1	
Check for stock pile, stock pile type, material type and determine the loading time	
Empty because no more entry	
Half time between cleanings	
=	
	0,00 min
Line 9/Column 2	
Check if second stock pile is in reach	
=	
Empty because no more stock piles	
Line 9/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of wheel-dozers	
	8

Line 10/Column 1	
Check for stock pile, stock pile type, material type and determine the loading time	
Empty because no more entry	
Half time between cleanings	
=	
	0,00 min
Line 10/Column 2	
Check if second stock pile is in reach	
=	
Empty because no more stock piles	
Line 10/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of wheel-dozers	
	8

F 51: Wheel-dozer stock pile calculation

9.4.3] Track-dozers at stock piles

Input stock pile	Input Material	Input Distance
Vliegveld	B	0
Bruce	A	3000 m
GR50	E	0
Sloep	D	2000 m
Bruce	C	0
GR50	D	0
0	0	0
0	0	0
0	0	0
0	0	

dump times stock piles	Komatsu 730E
A	3,66 min
B	2,58 min
C	2,12 min
D	2,12 min
E	2,83 min
L	1,77 min

Bruce	GR50	GR80	Sloep	Vliegveld
A	0	0	0	0
B	0	0	0	B
C	C	0	0	C
D	D	D	D	D
0	0	E	0	0
L	0	0	0	0

stock pile	
cycles	3 -
truck change	10,0 min
clean time wd	9,49 min
clean time td	8,74 min

machinery	average speed
CAT 834B	15,00 km/h
CAT D10R	7,00 km/h
CAT 16H	12,00 km/h
CAT 777C, D WT	19,00 km/h
CAT 777C, D	22,00 km/h
CAT 990C	10,00 km/h

distances	distances total
Vliegveld	5600 m
Dagbreek	4000 m
Sloep	3000 m
Bruce	7700 m
GR35	
GR50	
GR80	

Line 1/Column 1	
Check for stock pile, material type and determine the loading time	
	2,58 min
Half time between cleanings	
(3*2,58+(3-1)*10-8,74)/2=	
	9,50 min
Line 1/Column 2	
Check if second stock pile is in reach	
9,5-5600/(7*(1000/60))-8,74=	
No distance specified, therefore table: 5.600m	-47,24 min
Line 1/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of track-dozers	
039-05-CATD10R	1

Line 2/Column 1	
Check for stock pile, material type and determine the loading time	
	3,66 min
Half time between cleanings	
(3*3,66+(3-1)*10-8,74)/2=	
	11,12 min
Line 2/Column 2	
Check if second stock pile is in reach	
11,12-3000/(7*(1000/60))-8,74=	
	-23,33 min
Line 2/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of track-dozers	
303-CATD10R	2

Line 3/Column 1	
Check for stock pile, material type and determine the loading time	
Track-dozer is used for A, B, C and L material	Information: No Support
Half time between cleanings	
=	
	0,00 min
Line 3/Column 2	
Check if second stock pile is in reach	
=	
Empty because of no support	
Line 3/Column 3	
Check if third stock pile is in reach	
=	
Empty because of no support	0 min
Amount of track-dozers	
	2

Line 4/Column 1	
Check for stock pile, material type and determine the loading time	
Track-dozer is used for A, B, C and L material	Information: No Support
Half time between cleanings	
=	
	0,00 min
Line 4/Column 2	
Check if second stock pile is in reach	
=	
Empty because of no support	
Line 4/Column 3	
Check if third stock pile is in reach	
=	
Empty because of no support	0 min
Amount of track-dozers	
	2

Line 5/Column 1	
Check for stock pile, material type and determine the loading time	
	2,12 min
Half time between cleanings	
(3*2,12+(3-1)*10-8,74)/2=	
	8,81 min
Line 5/Column 2	
Check if second stock pile is in reach	
8,81-7700/(7*(1000/60))-8,74=	
	-65,93 min
Line 5/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of track-dozers	
304-CATD10R	3

Line 6/Column 1	
Check for stock pile, material type and determine the loading time	
Track-dozer is used for A, B, C and L material	Information: No Support
Half time between cleanings	
=	
	0,00 min
Line 6/Column 2	
Check if second stock pile is in reach	
=	
Empty because of no support	
Line 6/Column 3	
Check if third stock pile is in reach	
=	
Empty because of no support	0 min
Amount of track-dozers	
	3

Line 7/Column 1	
Check for stock pile, stock pile type, material type and determine the loading time	
Empty because no more entry	
Half time between cleanings	
=	
	0,00 min
Line 7/Column 2	
Check if second stock pile is in reach	
=	
Empty because no more stock piles	
Line 7/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of track-dozers	
	3

Line 8/Column 1	
Check for stock pile, stock pile type, material type and determine the loading time	
Empty because no more entry	
Half time between cleanings	
=	
	0,00 min
Line 8/Column 2	
Check if second stock pile is in reach	
=	
Empty because no more stock piles	
Line 8/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of track-dozers	
	3

Line 9/Column 1	
Check for stock pile, stock pile type, material type and determine the loading time	
Empty because no more entry	
Half time between cleanings	
=	
	0,00 min
Line 9/Column 2	
Check if second stock pile is in reach	
=	
Empty because no more stock piles	
Line 9/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of track-dozers	
	3

Line 10/Column 1	
Check for stock pile, stock pile type, material type and determine the loading time	
Empty because no more entry	
Half time between cleanings	
=	
	0,00 min
Line 10/Column 2	
Check if second stock pile is in reach	
=	
Empty because no more stock piles	
Line 10/Column 3	
Check if third stock pile is in reach	
=	
Zero because not reachable	0 min
Amount of track-dozers	
	3

F 52: Track-dozer stock pile calculation

9.4.4] Track-dozers at constructions

levels	3 -
angle	8 °
material to cut	120000,00 m³
material to fill	73745,75 m³
days	5 -
material	D -

material factors	construction
A	
B	
C	1,9 -
D	1,7 -
E	1,5 -
L	

construction time	7200 min

push cut	80,00%
push fill	30,00%

performance	9,73 m³/min

Line 1/Column 1	
Check for construction material	
	1,7 -
Push cut material	
((120000*1,7)/9,73)*0,8=	
	16765,58 min
Line 1/Column 2	
Summation of Column 1	
16765,58+3863,72=	
	20629,30 min
Line 1/Column 3	
Amount of track-dozers	
ROUNDUP(20629,3/7200,0)=	
305-307 CATD10R	3

Line 2/Column 1	
Check for construction material	
	1,7 -
Push fill material	
((73745,75*1,7)/9,73)*0,3=	
	3863,72 min

F 53: Track-dozer construction calculation

9.4.5] Graders for road maintaining

distances	cleaning	driving	distances total
Vliegveld	2000 m	5600 m	5600 m
Dagbreek	1200 m	4000 m	4000 m
Sloep	800 m	3000 m	3000 m
Bruce	600 m	3600 m	7700 m
GR35	1300 m	4100 m	
GR50	1000 m	3200 m	
GR80	500 m		

road width	22,62 m

machinery	average speed
CAT 834B	15,00 km/h
CAT D10R	7,00 km/h
CAT 16H	12,00 km/h
CAT 777C, D WT	19,00 km/h
CAT 777C, D	22,00 km/h
CAT 990C	10,00 km/h

work time per hour	40 min
work time per shift	480 min

used areas
1
2
3
4
0
6
0

Vliegveld performance	150,39 m³/min
Dagbreek performance	146,77 m³/min
Sloep performance	142,49 m³/min
Bruce performance	138,45 m³/min
GR35 performance	147,45 m³/min
GR50 performance	145,03 m³/min
GR80 performance	135,37 m³/min

Line 1/Column 1	
Grading Area	
2000*22,62=	
	45240,00 m²
Line 1/Column 2	
Time for cleaning	
45240/150,39=	
	300,82 min
Line 1/Column 3	
Check if value is under work time per shift	
300,82=	
	300,82 min
Line 1/Column 4	
Check if further area is in reach	
5600/(12*(1000/60))=	
	28,00 min
Amount of graders	
022-06 CAT16H	1

Line 4/Column 1	
Grading Area	
600*22,62=	
	13572,00 m²
Line 4/Column 2	
Time for cleaning	
13572/138,45=	
	98,03 min
Line 4/Column 3	
Check if value is under work time per shift	
331,94+15+98,03=	
	444,97 min
Line 4/Column 4	
Check if further area is in reach	
7700/(12*(1000/60))=	
	38,50 min
Amount of graders	
022-07 CAT16H	2

Line 7/Column 1	
Grading Area	
=	
Area not in use	0,00 m²
Line 7/Column 2	
Time for cleaning	
=	
Zero because not in use	
Line 7/Column 3	
Check if value is under work time per shift	
155,97=	
	155,97 min
Line 7/Column 4	
Check if further area is in reach	
=	
Zero because not reachable	0,00 min
Amount of graders	
240 CAT16H	3

Line 2/Column 1	
Grading Area	
1200*22,62=	
	27144,00 m²
Line 2/Column 2	
Time for cleaning	
27144/146,77=	
	184,94 min
Line 2/Column 3	
Check if value is under work time per shift	
184,94=	
Value is bigger than 480min	184,94 min
Line 2/Column 4	
Check if further area is in reach	
4000/(12*(1000/60))=	
	20,00 min
Amount of graders	
022-07 CAT16H	2

Line 5/Column 1	
Grading Area	
=	
Area not in use	0,00 m²
Line 5/Column 2	
Time for cleaning	
=	
Zero because not in use	
Line 5/Column 3	
Check if value is under work time per shift	
0=	
Value is bigger than 480min	0,00 min
Line 5/Column 4	
Check if further area is in reach	
=	
Zero because not reachable	0,00 min
Amount of graders	
240 CAT16H	3

Line 3/Column 1	
Grading Area	
800*22,62=	
	18096,00 m²
Line 3/Column 2	
Time for cleaning	
18096/142,49=	
	127,00 min
Line 3/Column 3	
Check if value is under work time per shift	
184,94+20+127=	
	331,94 min
Line 3/Column 4	
Check if further area is in reach	
3000/(12*(1000/60))=	
	15,00 min
Amount of graders	
022-07 CAT16H	2

Line 6/Column 1	
Grading Area	
1000*22,62=	
	22620,00 m²
Line 6/Column 2	
Time for cleaning	
22620/145,03=	
	155,97 min
Line 6/Column 3	
Check if value is under work time per shift	
0+155,97=	
	155,97 min
Line 6/Column 4	
Check if further area is in reach	
0/(12*(1000/60))=	
Zero because no more areas in use	0,00 min
Amount of graders	
240 CAT16H	3

F 54: Grader road maintenance calculation

9.4.6] Graders at constructions

levels	3 -
angle	8 °
material to cut	120000,00 m³
material to fill	73745,75 m³
days	5 -
material	D -

material factors	construction
A	
B	
C	1,9 -
D	1,7 -
E	1,5 -
L	

ramp repose angle	30 °
ramp width	22,62 m
ramp height	37,50 m
ramp length	470,25 m

construction time	7200 min

performance	42,20 m³/min

Line 1/Column 1	
Check for construction material	
	1,7 -
Time for grading	
(470,25*22,62*1,7)/42,2=	
	428,53 min
Line 1/Column 3	
Amount of graders	
ROUNDUP(428,53/7200,0)=	
241 CAT16H	1

F 55: Grader construction calculation

9.4.7] Water-trucks for road maintaining

distances	cleaning	driving	distances total
Vliegveld	2000 m	5600 m	5600 m
Dagbreek	1200 m	4000 m	4000 m
Sloep	800 m	3000 m	3000 m
Bruce	600 m	3600 m	7700 m
GR35	1300 m	4100 m	
GR50	1000 m	3200 m	
GR80	500 m		

machinery	average speed	bucket capacity
CAT 834B	15,00 km/h	7,75 m³
CAT D10R	7,00 km/h	22,00 m³
CAT 16H	12,00 km/h	4,88 m
CAT 777C, D WT	19,00 km/h	85,00 m³
CAT 777C, D	22,00 km/h	60,50 m³
CAT 990C	10,00 km/h	8,40 m³

work time per hour	40 min	60 min
work time per shift	480 min	720 min

used areas
1
2
3
4
0
6
0

pump rate	2,67 m³/min
emptying time	31,84 min
refilling time	19,00 min
water volume	0,00050 m³/m²
summer	14,16 -
winter	10,16 -

road width	28,00 m

Vliegveld performance	1,76 m³/min
Dagbreek performanc	2,08 m³/min
Sloep performance	2,30 m³/min
Bruce performance	2,42 m³/min
GR35 performance	2,04 m³/min
GR50 performance	2,19 m³/min
GR80 performance	2,49 m³/min

Line 1/Column 1	
Watering Area	
2000*14,16*0*28=	
	393,38 m³
Line 1/Column 2	
Time for watering	
393,38/4,25+(393,38/85)*19=	
	180,49 min
Line 1/Column 3	
Check if value is under work time per shift	
180,49=	
	180,49 min
Line 1/Column 4	
Check if further area is in reach	
5600/(19*(1000/60))=	
	17,68 min
Amount of water-trucks	
222-CAT777D	1

Line 4/Column 1	
Watering Area	
600*14,16*0*28=	
	118,01 m³
Line 4/Column 2	
Time for watering	
118,01/12,62+(118,01/85)*19=	
	35,73 min
Line 4/Column 3	
Check if value is under work time per shift	
307,52+11,37+35,73=	
	354,62 min
Line 4/Column 4	
Check if further area is in reach	
7300/(19*(1000/60))=	
	23,05 min
Amount of water-trucks	
222-CAT777D	1

Line 7/Column 1	
Watering Area	
500*14,16*0*28=	
	98,35 m³
Line 7/Column 2	
Time for watering	
98,35/14,69+(98,35/85)*19=	
	28,68 min
Line 7/Column 3	
Check if value is under work time per shift	
445,99+28,68=	
	474,67 min
Line 7/Column 4	
Check if further area is in reach	
=	
	0,00 min
Amount of graders	
222-CAT777D	1

Line 2/Column 1	
Watering Area	
1200*14,16*0*28=	
	236,03 m³
Line 2/Column 2	
Time for watering	
236,03/6,84+(236,03/85)*19=	
	87,25 min
Line 2/Column 3	
Check if value is under work time per shift	
180,49+17,68+87,25=	
	285,42 min
Line 2/Column 4	
Check if further area is in reach	
7000/(19*(1000/60))=	
	22,11 min
Amount of water-trucks	
222-CAT777D	1

Line 5/Column 1	
Watering Area	
=	
Area not in use	0,00 m³
Line 5/Column 2	
Time for watering	
=	
Zero because not in use	
Line 5/Column 3	
Check if value is under work time per shift	
354,62+23,05=	
	377,67 min
Line 5/Column 4	
Check if further area is in reach	
=	
Zero because not reachable	0,00 min
Amount of graders	
222-CAT777D	1

Line 3/Column 1	
Watering Area	
=	
	0,00 m³
Line 3/Column 2	
Time for watering	
0/9,85+(0/85)*19=	
	0,00 min
Line 3/Column 3	
Check if value is under work time per shift	
285,42+22,11=	
	307,52 min
Line 3/Column 4	
Check if further area is in reach	
3600/(19*(1000/60))=	
	11,37 min
Amount of water-trucks	
222-CAT777D	1

Line 6/Column 1	
Watering Area	
1000*14,16*0*28=	
	196,69 m³
Line 6/Column 2	
Time for watering	
196,69/8,08+(196,69/85)*19=	
	68,32 min
Line 6/Column 3	
Check if value is under work time per shift	
377,67+68,32=	
	445,99 min
Line 6/Column 4	
Check if further area is in reach	
0/(22*(1000/60))=	
Zero because no more areas in use	0,00 min
Amount of graders	
222-CAT777D	1

F 56: Water-truck road maintenance calculation

9.4.8] Dump-trucks for HMS hauling

distances	distances HMS
Vliegveld	6000 m
Dagbreek	3000 m
Sloep	1200 m
Bruce	300 m
GR35	2100 m
GR50	3300 m
GR80	4200 m

machinery	average speed
CAT 834B	15,00 km/h
CAT D10R	7,00 km/h
CAT 16H	12,00 km/h
CAT 777C, D WT	19,00 km/h
CAT 777C, D	22,00 km/h
CAT 990C	10,00 km/h

work time per hour	40 min
work time per shift	480 min

used areas
1
2
3
4
0
6
0

Vliegveld performance	1,08 m^3/min
Dagbreek performance	1,91 m^3/min
Sloep performance	3,55 m^3/min
Bruce performance	6,22 m^3/min
GR35 performance	2,49 m^3/min
GR50 performance	1,78 m^3/min
GR80 performance	1,46 m^3/min

Line 1/Column 1		
HMS Volume		
		377,33 m^3
Line 1/Column 2		
Time for hauling		
377,33/1,08=		
		349,23 min
Line 1/Column 3		
Check if value is under work time per shift		
349,23=		
		349,23 min
Amount of dump-trucks		
226-CAT777D		1

Line 4/Column 1		
HMS Volume		
		416,56 m^3
Line 4/Column 2		
Time for hauling		
416,56/6,22=		
		66,98 min
Line 4/Column 3		
Check if value is under work time per shift		
39,09+66,98=		
		106,07 min
Amount of dump-trucks		
232-CAT777D		2

Line 7/Column 1		
HMS Volume		
Area not in use		0,00 m^2
Line 7/Column 2		
Time for hauling		
=		
Zero because of not in use		
Line 7/Column 3		
Check if value is under work time per shift		
342,45=		
		342,45 min
Amount of dump-trucks		
232-CAT777D		2

Line 2/Column 1		
HMS Volume		
		238,70 m^3
Line 2/Column 2		
Time for hauling		
238,7/1,91=		
		124,85 min
Line 2/Column 3		
Check if value is under work time per shift		
349,23+124,85=		
		474,07 min
Amount of dump-trucks		
226-CAT777D		1

Line 5/Column 1		
HMS Volume		
Area not in use		0,00 m^2
Line 5/Column 2		
Time for haulinging		
=		
Zero because of not in use		
Line 5/Column 3		
Check if value is under work time per shift		
106,07=		
		106,07 min
Amount of dump-trucks		
232-CAT777D		2

Line 3/Column 1		
HMS Volume		
		138,85 m^3
Line 3/Column 2		
Time for hauling		
138,85/3,55=		
		39,09 min
Line 3/Column 3		
Check if value is under work time per shift		
39,09=		
Value is bigger than 480min		39,09 min
Amount of dump-trucks		
232-CAT777D		2

Line 6/Column 1		
HMS Volume		
		419,65 m^3
Line 6/Column 2		
Time for cleaning		
419,65/1,78=		
		236,38 min
Line 6/Column 3		
Check if value is under work time per shift		
106,07+236,38=		
		342,45 min
Amount of water-trucks		
232-CAT777D		2

F 57: Dump-truck HMS hauling calculation

9.4.9] Front-end-loaders for HMS loading

work time per hour	40 min
work time per shift	480 min

performance	4,20 m^3/min

Line 1/Column 1		
HMS Volume		
		1591,09 m^3
Time for loading		
1591,09/4,2=		
		378,95 min
Line 1/Column 3		
Amount of front-end-loader		
ROUNDUP(378,95/480,0)=		
134-01 CAT990C		1

F 58: Front-end-loader HMS loading calculation

9.5] Calculation results

KUMBA IRON ORE

Sishen Iron Ore Company (Pty) Ltd

Results of calculation of secondary equipment

Date:	02/11/2007 14:57
Person responsible:	Christian Comoli

Project Titel:	test

WHEEL-DOZER:	total	availibility		use of availibility	
	10	12	(11,11)	14	(13,1)

	Nr.	shovel numbers	machine number	machine type
E	1	Material		
	2	561	024-03	CAT 834B
	3	562	316	CAT 834B
	4	563	316	CAT 834B
E	5	Shovel nr.		
	6	565	317	CAT 834B
	7	566	318	CAT 834B
	8	22	319	CAT 834B
	9	23	320	CAT 834B

	Nr.	stock piles	machine number	machine type
	10	VliegveldB	321	CAT 834B
	11	BruceA	322	CAT 834B
I	12	No support		
E	13	Material type		
	14	BruceC	323	CAT 834B
	15	GR80D	324	CAT 834B

Nr.	additional	machine number	machine type
16		401	Komatsu WD600-3
17		402	Komatsu WD600-3
18		403	Komatsu WD600-3
19		n.m.a.	

I Information

E Error

n.m.a. no machine availible

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KUMBA IRON ORE

Sishen Iron Ore Company (Pty) Ltd

Results of calculation of secondary equipment

Date:	02/11/2007 14:57
Person responsible:	Christian Comoli

Project Titel:	test

TRACK-DOZER:	total	availibility	use of availibility
	8	10 (9,1)	13 (12,7)

Nr.	stock piles	machine number	machine type
1	GR80E	039-05	CAT D10R

Nr.	selective	machine number	machine type
2		303	CAT D10R

Nr.	levelling	machine number	machine type
3	blast blocks	304	CAT D10R
4	shovel area	305	CAT D10R

Nr.	construction	machine number	machine type
5		306	CAT D10R
6		307	CAT D10R
7		308	CAT D10R
8		309	CAT D10R

Nr.	additional	machine number	machine type
9		310	CAT D10R
10		311	CAT D10R
11		430	CAT D10T
12		431	CAT D10T
13		432	CAT D10T

E Error n.m.a. no machine availible

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KUMBA IRON ORE

Sishen Iron Ore Company (Pty) Ltd

Results of calculation of secondary equipment

Date:	02/11/2007 14:57
Person responsible:	Christian Comoli

Project Titel:	test

GRADER:	total	availibility	use of availibility
	4	6 (5)	6 (5,8)

Nr.	road maintaining	machine number	machine type
1	Vliegveld	022-06	CAT 16H
2	Dagbreek	022-07	CAT 16H
3	Sloep	022-07	CAT 16H
4	Bruce	022-07	CAT 16H
5	GR35	022-07	CAT 16H
6	GR50	240	CAT 16H
7	GR80	240	CAT 16H

Nr.	construction	machine number	machine type
8		241	CAT 16H

Nr.	additional	machine number	machine type
9		242	CAT 16H
10		243	CAT 16H

I Information

E Error

n.m.a. no machine availible

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KUMBA IRON ORE

Sishen Iron Ore Company (Pty) Ltd

Results of calculation of secondary equipment

Date:	02/11/2007 14:57
Person responsible:	Christian Comoli

Project Titel:	test

WATER-TRUCK:	total	availibility	use of availibility
	1	2 (1,1)	2 (1,3)

Nr.	road maintaining	machine number	machine type
1	Vliegveld	222	CAT 777D
2	Dagbreek	222	CAT 777D
3	Sloep	222	CAT 777D
4	Bruce	222	CAT 777D
5	GR35	222	CAT 777D
6	GR50	222	CAT 777D
7	GR80	222	CAT 777D

Nr.	additional	machine number	machine type
8		224	CAT 777D

n.m.a. no machine availible

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KUMBA IRON ORE

Sishen Iron Ore Company (Pty) Ltd

Results of calculation of secondary equipment

Date:	02/11/2007 14:57
Person responsible:	Christian Comoli

Project Titel:	test

DUMP-TRUCK:	total	availibility		use of availibility	
	4	5	(4,2)	5	(4,9)

Nr.	HMS transport	machine number	machine type
1	Vliegveld	232	CAT 777D
1		233	CAT 777D
2	Dagbreek	233	CAT 777D
3	Sloep	233	CAT 777D
4	Bruce	234	CAT 777D
5	GR35	234	CAT 777D
6	GR50	234	CAT 777D
7	GR80	236	CAT 777D

Nr.	additional	machine number	machine type
8		237	Komatsu HD785-5

n.m.a. no machine availible

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KUMBA IRON ORE

Sishen Iron Ore Company (Pty) Ltd

Results of calculation of secondary equipment

Date:	02/11/2007 14:57
Person responsible:	Christian Comoli

Project Titel:	test

FRONT-END-LOADER:	total	availibility	use of availibility
	2	3 (2,7)	4 (3,5)

Nr.	HMS loading	machine number	machine type
1	dump trucks	134-01	CAT 990C
2	dump trucks	340	CAT 990C

Nr.	additional	machine number	machine type
3		341	CAT 990C
4		n.m.a.	

n.m.a. no machine availible

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KUMBA IRON ORE

Sishen Iron Ore Company (Pty) Ltd

Results of calculation of secondary equipment

Date:	02/11/2007 14:57
Person responsible:	Christian Comoli

Project Titel:	test

TRACK-DOZER:	13	work time & fuel

	work time per shift	fuel
1	CAT D10R - 039-05	
	94,76 min	54,74 l
2	CAT D10R - 303	
	313,74 min	181,24 l
3	CAT D10R - 304	
	232,50 min	134,31 l
4	CAT D10R - 305	
	250,52 min	144,71 l
5	CAT D10R - 306	
	368,38 min	212,80 l
6	CAT D10R - 307	
	368,38 min	212,80 l
7	CAT D10R - 308	
	368,38 min	212,80 l
8	CAT D10R - 309	
	368,38 min	212,80 l
9	CAT D10R - 310	
	0,00 min	0,00 l
10	CAT D10R - 311	
	0,00 min	0,00 l
11	CAT D10T - 430	
	0,00 min	0,00 l
12	CAT D10T - 431	
	0,00 min	0,00 l
13	CAT D10T - 432	
	0,00 min	0,00 l

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KUMBA IRON ORE

Sishen Iron Ore Company (Pty) Ltd

Results of calculation of secondary equipment

Date:	02/11/2007 15:03
Person responsible:	Christian Comoli

Project Titel:	test

GRADER:	6	work time & fuel

work time per shift	fuel	material
1 CAT 16H - 022-06		
372,37 min	215,11 l	56000 m³
2 CAT 16H - 022-07		
439,78 min	254,04 l	106400 m³
3 CAT 16H - 240		
296,49 min	171,27 l	42000 m³
4 CAT 16H - 241		
42,85 min	24,75 l	
5 CAT 16H - 242		
0,00 min	0,00 l	
6 CAT 16H - 243		
0,00 min	0,00 l	

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KUMBA IRON ORE

Sishen Iron Ore Company (Pty) Ltd

Results of calculation of secondary equipment

Date:	02/11/2007 15:03
Person responsible:	Christian Comoli

Project Titel:	test

WATER-TRUCK:	2	work time & fuel

	work time per shift	fuel	material
1 CAT 777D - 222			
	474,67 min	274,20 l	1042,47 m³
2 CAT 777D - 224			
	0,00 min	0,00 l	

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KUMBA IRON ORE

Sishen Iron Ore Company (Pty) Ltd

Results of calculation of secondary equipment

Date:	02/11/2007 15:19
Person responsible:	Christian Comoli

Project Titel:	test

DUMP-TRUCK:	5	work time & fuel

work time per shift	fuel	material
1 CAT 777D - 232		
480,00 min	277,28 l	393,38 m³
2 CAT 777D - 233		
450,42 min	260,19 l	629,41 m³
3 CAT 777D - 234		
455,69 min	263,23 l	314,71 m³
4 CAT 777D - 236		
44,58 min	25,75 l	295,04 m³
5 Komatsu HD785-5 - 237		
0,00 min	0,00 l	

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KUMBA IRON ORE

Sishen Iron Ore Company (Pty) Ltd

Results of calculation of secondary equipment

Date:	02/11/2007 15:19
Person responsible:	Christian Comoli

Project Titel:	test

FRONT-END-LOADER:	4	work time & fuel

work time per shift	fuel	material
1 CAT 990C - 134-01		
480,00 min	277,28 l	1139,09 m³
2 CAT 990C - 340		
2,00 min	1,16 l	1139,09 m³
3 CAT 990C - 341		
0,00 min	0,00 l	
4 - n.m.a.		

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F 59: Results of the calculation

10 References

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