. 1 No Caterpillar 140G grader – this unit is suggested as a supplement to the dozer/compactor combination and, possibly, for the initial placement of the topsoil on the rehabilitation area.

4.1 Capex

The following budget prices have been supplied telephonically:

O + K RH4	backhoe	R 78 000
Cat 140G	grader with scarifier	R153 000
14/10	concrete mixer	R 7 300

4.2 Opex

The operating cost calculations for the above plant are shown in Appendix 4.1. These calculations are considered to have $\pm$ 25% cost confidence.

Total annual opex is summarised in Table 4.

Machine	Ownership Opex/OH (R)	Operating Opex/OH (R)	Total Opex/OH (R)	Operating Hours per annum	Annual Opex (R)
O + K RH4	18,60	12,55	31,15	1040	32 400
Cat 140G	31,24	19,80	51,04	1040	53 100
TOTAL				. .	85 500

5 OVERVIEW OF EQUIPMENT REQUIREMENTS

The total fleet recommendations for the Tutuka ash dump operations are as follows (optional fleet are shown with *):

1 No Caterpillar D7 bulldozer   )
1 No Caterpillar 814C bulldozer) or 2 No Caterpillar D7 bulldozer

1 No   O + K L7 front end loader

3 No Leyland 3,5m^3 tip truck

1 No   6 t (static) Compactor

1 No   Water bowser*

1 No   O + K RH4 backhoe*

1 No   Caterpillar 140G grader*

1 No   14/10 concrete mixer*

It should be noted that the specific makes of machine have been used to indicate the capacities of those machines and are not purchase recommendations.

6   EQUIPMENT MAINTENANCE AND REPAIR

6.1   Maintenance

Without full knowledge of the plant to be employed at Tutuka, and the duty cycles of the individual items, the subject of equipment maintenance and repair can only be addressed conceptually.

A letter from N Schnuir of Barlows Tractor Division to the author is included as Appendix 6.1. In this letter three options for after-sales service are outlined. These options essentially range from full support, through partial support, to analystical inspection.

The plant suggested for ash dump operations should be highly mobile with the exception of the tracked dozer. For the mobile equipment servicing should be undertaken at a central maintenance facility.

The tracked dozer is only scheduled to operate for 1 300 hours per annum. Daily maintenance should be conducted by the operator (all manufacturers offer an operator training service). Lubrication services will be required every 250 hours and these can be undertaken in the field. Every 1000 hours an analytical service should be undertaken (oil analyses etc). Again, this service can be a field service.

It follows from the above, that no provision need be made for a field workshop advancing with the ash dump. In the event of a major breakdown of the tracked dozer then the machine would be taken to the central workshop - this would, however, be a rare occurrence.

6.2 Field servicing

It is suggested that a field service truck, equipped with oil dispensers, a vacuum extraction pump (for removing used oils), a compressor (for cleaning air filters) and a steam cleaning unit - plus tool storage facilities - be equipped for Tutuka. A 500 litre fuel bowser should also be supplied. The bowser will be towed behind the service truck when required.

A service truck equipped as outlined above will be able to support all of the scheduled equipment in the field on a daily basis. With adequate oil dispensing and extraction systems, efficient 250 hour services can also be effected.

In view of the working conditions, regular cleaning of air filter and steam cleaning of the equipment is recommended. Regular cleaning is also a very necessary part of any planned maintenance system.

6.3 General

With reference to the letter reproduced in Appendix 6.1 the following observations are made:

. The services offered by Barlows are also offered by other manufacturers

. Option C is considered to have merit for Tutuka, due to the light duty of the equipment

. A visit to Middelburg would be beneficial for Escom person-
nel to gain first hand experience of the types of services
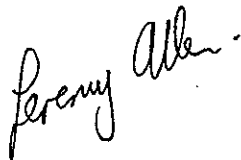and facilities that would match the Tutuka requirements.

Costings have not been included in this section as no
preliminary design work has been undertaken.

7   SUMMARY OF COSTS

Total capex for the minimum fleet will be approximately R565 000 ex
gst.

Operating costs per annum for the corresponding fleet amount to
approximately R265 000.

The capital cost per annual cubic metre of ash deposited (7 083
m^3/day average) amounts to R0,31 with the equivalent opex figure
of R0,14.

JEREMY P ALLEN

A P P E N D I C E S

STEFFEN ROBERTSON & KIRSTEN

APPENDICES

APPENDIX 1.1

ASH PRODUCTIONS

AT FULL PRODUCTION   FORWARD STACK   9500 m³/day

FILL DEPTH (m)	VOLUME OF FILL (m³ pr m)	VOLUME TO BE DOZED (m³ pr m) 1:3 slope	RATE OF ADVANCE (m pr day)	VOLUME TO BE DOZED (m³ pr day)	AREA TO BE LEVELLED (m²)(top surface only)	VOLUME TO BE LEVELLED (Assume 500 mm deep)	TOTAL VOLUME TO BE DOZED m³
5	150	10	63	633	1900	950	1583
10	300	25	32	792	950	475	1267
15	450	65	21	1371	633	317	1688
25	750	180	13	2280	380	190	2470
35	1050	400	9	3620	272	136	3756

AT FULL PRODUCTION   BACK STACK   9500 m³/day

FILL DEPTH (m)	VOLUME OF FILL (m³ per m)	AREA TO BE LEVELLED (m² per m)	RATE OF ADVANCE (m per day)	VOLUME TO BE DOZED (Assure 500 mm deep)(m³)
9	270	58	35	1021

APPENDIX 1.2

BULLDOZER PRODUCTION

1 ASSUMPTIONS

- 60 minute hour.
- Machine cuts for 30 m and then drifts (conservative).
- Soil density of 1370 kg/m^3.
- Coefficient of traction exceeds 0,5.

2 FACTORS

		Track dozer factor	Rubber tyre factor
Material density (actual)	1100 kg/m^3	1,25	1,25
Operator competence	average	0,75	0,60
Working gradient	- 40%	1,25	1,25
Dozing technique	Slot	1,10	1,20
Material type	Loose stockpile	1,20	1,20
Overall correction factor		1,54	1,23

3 PRODUCTION RATE

Machine	Unadjusted Hourly production (m^3)	Factored Hourly production (m^3)
Caterpillar D8	950	1463
Caterpillar D7	550	847
Caterpillar D6	270	416
Caterpillar 824	500	615
Caterpillar 814	400	492

APPENDIX 1.2 (Contd...)

4   VOLUME TO BE DOZED PER DAY

	Average	Maximum
Volume to be dozed (m^3)	2000	3800
Re-handling (assume 100 %)	2000	3800
Total volume handled	4000	7600

5   PROBABLE DOZER UTILISATION

	Productivity (m^3/hr)	Average Work Hours	Average Overall Utilisation (%)	Maximum Work Hours	Maximum Overall Utilisation (%)
D8	1463	2,73	27	5,19	52
D7	847	4,72	47	8,97	90
D6	416	9,62	96	—	—
824	615	6,50	65	—	—
814	492	8,13	81	—	—
Assumed overall utilisation			60		60

APPENDIX 1.3 (a)

HOURLY OWNING AND OPERATING COST ESTIMATE　　　　DATE: 31/01/84

A	Machine designation	CAT D8L
B	Estimated ownership period (years)	5
C	Estimated Usage (hours/year) (3 x 260)	780,00
D	Ownership usage (total hours)	3900,00

OWNING COST

E	Delivered price	380000,00
F	Less tyre replacement cost	–
G	Delivered price less tyres	380000,00
H	Less residual value at replacement (40%)	152000,00
I	Value to be recovered through work	228000,00
J	Ownership cost per hour	58,46

K　Interest costs: $\dfrac{\frac{B+1}{2B} \times G \times \text{Interest Rate (16\%)}}{C}$　　46,77

L　Insurance: $\dfrac{\frac{B+1}{2B} \times G \times \text{Insurance Rate (1\%)}}{C}$　　2,92

M　Property tax $\dfrac{\frac{B+1}{2B} \times G \times \text{Tax Rate \% (1\%)}}{C}$　　2,92

N　TOTAL HOURLY OWNING COST　　111,07

OPERATING COSTS

a Fuel: Unit price (c/l)   50
         Consumption (l/hr)   35   17,50

b Lubes, Oils, Filters, Grease (10% of a)   1,75

c Tyre replacement: Tyre cost (R)   N/A
                      Life in hours   N/A   N/A

d Undercarriage cost: Impact   0,1
                       Abrasiveness   0,4
                       Z factor   0,5
                       TOTAL   1,0
                       Basic factor   11,5   12,65

e Repair reserve: Extended use ult.   1,0
                    Basic repair factor   7,0   7,70

f Special wear items: Item cost   N/A
                        Life in hours   N/A   N/A

g TOTAL OPERATING COST   39,60

NB Rand to $ factor of 1.1 applied in d and e.

*Operating cost excludes operator wage.

APPENDIX 1.3 (b)

HOURLY OWNING AND OPERATING COST ESTIMATE   DATE: 31/01/84

A Machine designation   CAT D7
B Estimated ownership period (years)   5
C Estimated Usage (hours/year)   (5 x 260)   1300,00
D Ownership usage (total hours)   6500,00

OWNING COST

E Delivered price   215000,00
F Less tyre replacement cost   —
G Delivered price less tyres   215000,00
H Less residual value at replacement (30%)   64500,00
I Value to be recovered through work   150500,00
J Ownership cost per hour   23,15

K Interest costs: $\dfrac{\frac{B + 1}{2B} \times G \times \text{Interest Rate (16\%)}}{C}$ 15,88

L Insurance: $\dfrac{\frac{B + 1}{2B} \times G \times \text{Insurance Rate (1\%)}}{C}$ 0,99

M Property tax $\dfrac{\frac{B + 1}{2B} \times G \times \text{Tax Rate \% (1\%)}}{C}$ 0,99

N TOTAL HOURLY OWNING COST   41,01

OPERATING COSTS

a Fuel: Unit price (c/l)   50

           Consumption (1/hr)   29   14,50

b Lubes, Oils, Filters, Grease (10% of a)   1,45

c Tyre replacement: Tyre cost (R)   N/A

                      Life in hours   N/A   N/A

d Undercarriage cost: Impact   0,1

                    Abrasiveness   0,4

                    Z factor   0,5

                    TOTAL   1,0

                    Basic factor   9,0   9,90

e Repair reserve: Extended use ult.   1,0

                Basic repair factor 6,0   6,60

f Special wear items: Item cost   N/A

                    Life in hours   N/A   N/A

g TOTAL OPERATING COST   32,45

NB Rand to $ factor of 1.1 applied in d and e.

*Operating cost excludes operator wage.

APPENDIX 1.3 (c)

| HOURLY OWNING AND OPERATING COST ESTIMATE | DATE: 31/01/84 |

A	Machine designation	CAT 814
B	Estimated ownership period (years)	5
C	Estimated usage (hours / year) (260 x 6)	1560,00
D	Ownership usage (total hours)	7800,00

OWNING COSTS

E	Delivered Price	231000,00
F	Less tyre replacement cost	16000,00
G	Delivered price less tyres	215000,00
H	Less residual value at replacement (30%)	64500,00
I	Value to be recovered through work	150500,00
J	Ownership cost per hour	19,29

K Interest costs: $\dfrac{\dfrac{B+1}{2B} \times G \times \text{Interest Rate (16\%)}}{C}$ 13,23

L Insurance: $\dfrac{\dfrac{B+1}{2B} \times G \times \text{Insurance Rate (1\%)}}{C}$ 0,83

M Property tax $\dfrac{\dfrac{B+1}{2B} \times G \times \text{Tax Rate (1\%)}}{C}$ 0,83

N TOTAL HOURLY OWNING COST   34,18

OPERATING COSTS

a	Fuel: Unit price (c/l)	50	
	Consumption (l/hr)	23	11,50
b	Lubes, Oils, Filters, Grease (10% of a)		1,15
c	Tyre replacement: Tyre cost (R)	16 000	
	Life in hours	6 000	2,67
d	Undercarriage cost: Impact	N/A	
	Abrasiveness	N/A	
	Z factor	N/A	
	TOTAL	N/A	
	Basic factor	N/A	N/A
e	Repair extended use mult.	]	
	Basic repair factor	]	5,50
f	Special wear items: Item cost	]	
	Life in hours	]	0,60
g	TOTAL OPERATING COST		21,42

*Operating cost excludes operator wage.

APPENDIX 1.5

COMPARISON OF BULLDOZER

POWER AND WEIGHT

ITEM	FLYWHEEL POWER (KW)	%AGE EXCESS (-VE)	OPERATING MASS (KG)	%AGE EXCESS (-VE)
PHB-WESERHUTTE RECOMMENDATION	130		20 000	
CAT D7	149	15	20 095	0
CAT D8	250	92	37 479	87
CAT 814 B	157	21	20 927	5
CAT 824 C	231	78	30 380	52

NB Operating mass quoted is less conveyor moving attachments.

Refer telex in Appendix 1.4 for shifting speeds etc.

APPENDIX 1.6

TOWING LIMITATIONS ON CAT 814 B DOZER

1 The requirement is for the dozer to tow a compactor, with grade, on a one in three slope.

2 An average rolling resistance of 3% (33 kg per ton of weight) is assumed.

3 Operating mass of 814 B is 20 927 kg.

4 Co-effecient of traction of 814 B should be approximately 0,45 in this application (Caterpillar Handbook).

Calculation

Slope of 1:3   18,43°
Sine 18,43° = 0,32
Cosine 18,43°= 0,95

Therefore component of 814 B mass available to hold compactor is

$$0,95. \ 10\ 927. \ 0,45 \ = \ 8\ 934 \ kg$$

Rolling coponenet of 814 B and compactor (mass = x kg) is

$$(1 - 0,03) \ (20\ 927 + x) \ (0,32) \ = \ (6\ 496 + 0,31x) \ kg$$

Therefore maximum mass of compactor (x kg) must be

$$\left[\frac{8934 - 6496}{0,31}\right] = 7\ 850 \ kg$$

As no compactor inertia has been considered the mass of 7 850 kg is considered a conservative figure.

APPENDIX 3.1

TRUCK/SHOVEL PRODUCTIVITY

1 EQUIPMENT

Diesel powered hydraulic excavator with $0,8$ m^3 bucket.

Diesel powered articulated dump truck $3,5$ m^3 capacity.

2 ASSUMPTIONS

Haul distance   4 000 m.

Hauling time (loaded and empty) 15 minutes.

Loading time (5 swings @ 0,5 mins, 0,5 mins transfer time) 3 minutes.

Dumping time 2 minutes.

Bucket fill factor 85%.

Volume movement per day 175 m^3

Overall equipment utilisation 60%.

3 PRODUCTIVITY

Truck – Productive hours per day (10.0,6)   =   6

      Truck loads per day ((6.60)/20)   =   18

      Volume capacity per day (18.10)   =   63 m^3/truck

      Three trucks covers production requirements.

Loader– Truck loads per day   =   50

      Load time per truck   =   2,5 minutes

      Load time per day (2,5.18)   = 125 minutes

      Loader utilisation $\left(\frac{125}{10.60}\right) = 21\%$

From the above figures it is apparent that the loader will be underutilized.

APPENDIX 3.2 (a)

HOURLY OWNING AND OPERATING COST ESTIMATE   DATE: 31/01/84

A	Machine designation	O + K L7
B	Estimated ownership period (years)	5
C	Estimated usage (hours / year) (4 x 260)	1040,00
D	Ownership usage (total hours)	5200,00

OWNING COSTS

E	Delivered price	56000,00
F	Less tyre replacement cost	4200,00
G	Delivered price less tyres	51800,00
H	Less residual value at replacement (30%)	20720,00
I	Value to be recoved through work	31080,00
J	Ownership cost per hour	5,98

K   Interest costs: $\dfrac{\frac{B + 1}{2B} \times G \times \text{Interest Rate (16\%)}}{C}$ 4,78

L   Insurance: $\dfrac{\frac{B + 1}{2B} \times G \times \text{Insurance Rate (1\%)}}{C}$ 0,30

M   Property tax $\dfrac{\frac{B + 1}{2B} \times G \times \text{Tax Rate \% (1\%)}}{C}$ 0,30

N   TOTAL HOURLY OWNING COST   11,36